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42nd Annual Report of FORAGE RESEARCH in Northeastern United States

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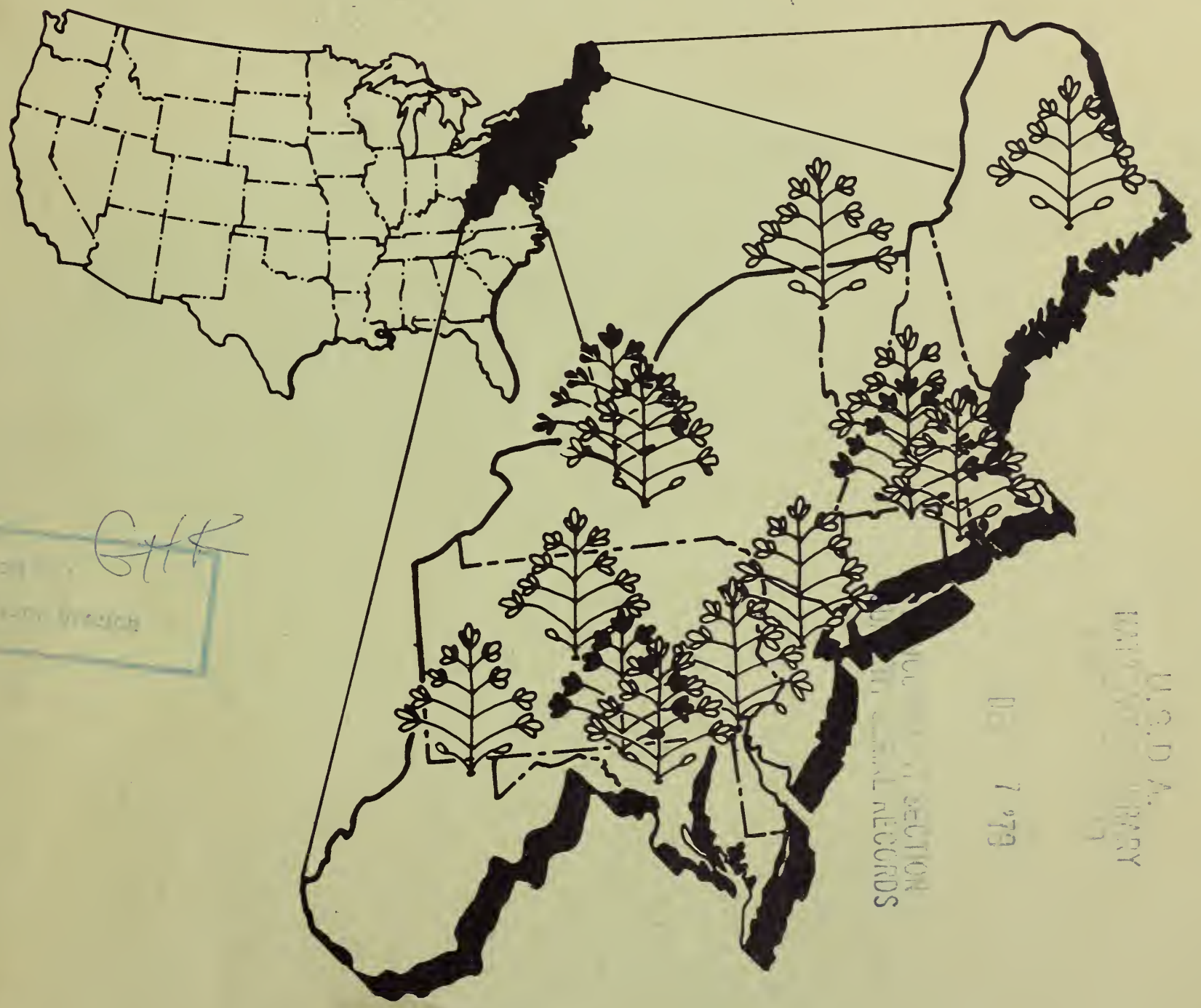

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1978

A Joint Contribution of the

U.S. REGIONAL PASTURE RESEARCH LABORATORY

and

BELTSVILLE AGRICULTURAL RESEARCH CENTER

and

AGRICULTURAL EXPERIMENT STATIONS
OF THE 12 NORTHEASTERN STATES

Participating Agencies

BELTSVILLE AGRICULTURAL RESEARCH CENTER,
CHESAPEAKE-POTOMAC AREA, and
NORTH ATLANTIC AREA

of the

Northeastern Region
Agricultural Research
Science and Education Administration
U.S. Department of Agriculture

and

Agricultural Experiment Stations

of

CONNECTICUT	NEW HAMPSHIRE	PENNSYLVANIA
DELAWARE	NEW JERSEY	RHODE ISLAND
MAINE	NEW YORK (ITHACA)	VERMONT
MARYLAND	NEW YORK (GENEVA)	WEST VIRGINIA
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TABLE OF CONTENTS

	Page
PREFACE	xi
AUTHOR INDEX	xii
ROSTER OF RESEARCH AND EXTENSION WORKERS IN NORTHEASTERN UNITED STATES WITH FORAGE CROPS AND GRASSLANDS ORIENTATION	xv
SECTION I. BREEDING, GENETICS, AND PLANT INTRODUCTION RESEARCH	1
Forage Breeding and Quality (J. S. Shenk)	2
Improvement of Birdsfoot Trefoil by Breeding (H. M. Schaaf)	2
Breeding Crownvetch for Forage and Slope Stabilization Usage (T. A. Long and M. L. Risius)	3
Breeding and Cytogenetic Investigations and Improvement of Cool-Season Perennial Forage Species (C. C. Lowe and R. P. Murphy)	3
Breeding Alfalfa for Tolerance to Aluminum Toxicity in Acid Soils (J. H. Elgin, Jr., J. E. McMurtrey, III, and C. D. Foy)	4
Regulation of Apomixis in Forage Grasses (R. T. Sherwood and B. A. Young)	5
Breeding Tall Fescue for Tolerance to Acid Soil Conditions (J. J. Murray, J. B. Powell, and C. D. Foy)	5
Improvement of Forage Quality in Alfalfa by Breeding (C. C. Lowe, R. P. Murphy, and J. E. Sumberg)	6
Breeding Red Clover and Alfalfa (Project PENO 2290) (R. W. Cleveland, M. L. Risius, and J. S. Shenk)	6
New Polyploid Breeding Populations in Alfalfa for Improvement of Yield and Nutritive Value (R. P. Murphy and C. C. Lowe)	7
Selection for Lignin and Phosphorus Concentration in Alfalfa (R. R. Hill, Jr.)	7
Breeding Alfalfa for Disease and Insect Resistance (J. H. Elgin, Jr., J. E. McMurtrey, III, S. A. Ostazeski, and T. C. Elden)	8
Breeding Cool-Season Forage Species for Improved Feeding Value and Productivity (C. C. Lowe and R. P. Murphy)	9
Forage Grass Breeding, Genetics, and Cytology (J. B. Powell and N. R. O'Neill)	10
Forage Breeding (J. S. Shenk)	10
Genetic Variation for Nonstructural Carbohydrate Concentration in Tall Fescue (Festuca arundinacea Schreb.) (John A. Balasko, William V. Thayne, and Patrick M. O'Brien)	11

Plant Germplasm--Its Introduction, Testing, Multiplication, and Preservation (Desmond D. Dolan, William R. Sherring, and Bart J. Fiori). 12

SECTION II. ENTOMOLOGY RESEARCH. 18
Selection for Potato Leafhopper Resistance in Alfalfa (T. C. Elden and J. H. Elgin, Jr.) 19
Alfalfa Quality Models for Use in Pest Management Studies of the Alfalfa Ecosystem (G. W. Fick, R. G. Helgesen, and C. C. Lowe). 19
Control and Bionomical Studies of Livestock and Animal Food Crop Insects in West Virginia (Linda Butler, J. E. Weaver, and J. W. Amrine) 20
Flea Beetle Control on Conventional and Min-till Forage Kale (H. E. Reed and R. A. Byers) 20
Evaluation of Perennial Ryegrass Cultivars for Hairy Chinch Bug Resistance (R. H. Ratcliffe, J. J. Murray, and P. B. Baker) 21
Impact of Insects and Slugs Upon Establishment of Legumes in Grassland (Robert A. Byers, W. C. Templeton, Jr., and R. L. Mangan). 21
Life Table for the Alfalfa Blotch Leafminer (J. A. Plummer and R. A. Byers). 22
Antibiotic Resistance in *Bacillus thuringiensis* and *B. popilliae*: Plasmid DNA Transformation (Robert M. Faust). 22
Host Preference of *Sitona hispidulus* Larvae Among Legumes (R. A. Byers and W. A. Kendall). 22

SECTION III. PLANT PATHOLOGY RESEARCH. 23
Survey of Alfalfa Root Rot in Pennsylvania (K. T. Leath, R. R. Hill, and W. A. Priddy). 24
Diseases of Warm-Season Forage Grasses (K. E. Zeiders). 24
Decline of Alfalfa Due to *Meloidogyne hapla* in Pennsylvania (M. G. Bookbinder, K. T. Leath, J. R. Bloom, and F. L. Lukezic). 25
Effect of Magnesium on Stemphylium Leaf Spot of Alfalfa (K. T. Leath and C. F. Gross). 25
A *Septoria* Disease of Reed Canarygrass (K. E. Zeiders). 25
Studies on the Biochemistry of Plant Pathogenesis (D. L. Gustine and B. G. Moyer). 26
Plant Resistance and Pathogen Ecology in Relation to Infection of Forage Crops (R. L. Millar). 26
A Variable-spored Isolate of *Bipolaris* Pathogenic on Orchardgrass and Corn (K. E. Zeiders) 27

SECTION IV. GROWTH, PHYSIOLOGY, AND CLIMATIC EFFECTS 28
Feasibility of Perennial Ryegrass and Hybrid Derivatives as Northern Forage Crops (G. M. Wood, R. P. Cohen, and J. G. Welch). 29
Influence of Climatic Factors and Fertilization with N, K, and Mg on Uptake of Ions by Grass and Small-Grain Forages (R. Ellis, Jr., and D. L. Grunes). 30
Lime Responses of Kentucky Bluegrass, Tall Fescue, and Fineleaf Fescue Cultivars on an Acid, Aluminum-toxic Soil (J. J. Murray, L. C. Taylor, and G. Jones). 31
Intercropping Beans and Corn (M. B. Materu and W. B. Bryan) 31
Prediction of Alfalfa Production for Forage Systems Analysis (G. W. Fick, R. A. Milligan, and C. J. Sniffen) 31
Improved Biological Nitrogen Fixation in Forage Legumes and Grasses (L. D. Owens and C. Sloger). 32
Forage-Livestock Systems for Land with Soil and Site Limitations (W. C. Stringer, T. W. Bowersox, W. L. Kjelgaard, R. H. Fox, E. J. Partenheimer, and L. L. Wilson). 33
Ecology of Grasses and Legumes (Milton A. Sprague) 34
Physiological Processes Associated with Regrowth of Alfalfa (D. W. Koch and T. R. Peoples). 34
Effects of Genotypes and Environments on Growth and Feeding Quality of Forages (W. A. Kendall and W. C. Templeton, Jr.). 35
Preliminary Observations from a Study of the Vegetation on Open and Forested Uplands in Pennsylvania (D. A. Devlin, T. W. Bowersox, W. C. Stringer, L. L. Wilson, and M. A. Lucas) 35

SECTION V. WEED INVESTIGATIONS 36
Resistance of T-68 Birdsfoot Trefoil to 2,4-D (H. M. Schaaf and D. L. Linscott). 37
Weed Control in Birdsfoot Trefoil Seed Fields (D. L. Linscott and R. H. Vaughan) 37
Biological Control of Thistles Attempted (S. W. T. Batra) 37
Weed Control in No-tillage Forage Establishment Systems (D. L. Linscott and E. B. Rayburn) 38
Economic Losses Due to Weeds--Forage Legumes (D. L. Linscott, R. A. Peters, W. H. Mitchell, V. H. Holyoke, J. V. Parochetti, J. Vengris, J. B. Mitchell, R. D. Ilnicki, J. R. Justin, J. A. Meade, J. F. Hunt, R. R. Seaney, J. E. Baylor, N. L. Hartwig, R. C. Wakefield, T. R. Flanagan, O. E. Shubert, and C. B. Sperow) 40

Forage-Livestock Systems for Land with Soil and Site Limitations (D. W. Koch). 44
Post Establishment Year Comparisons of Conventional and Minimum Tillage Seedings of Alfalfa into Quackgrass (D. W. Koch and G. W. Mueller-Warrant). . . . 44
Annual and Perennial Weed Control in Corn and Forages (Nathan L. Hartwig). 45

SECTION VI. MANAGEMENT AND PRODUCTION RESEARCH 46
Alfalfa Variety Trials (L. R. Vough, J. H. McNemar, and N. A. Clark) 47
Alfalfa: Competition and Yield (N. J. Chatterton and G. E. Carlson) 47
Contribution to Forage Yield of Alfalfa, Red Clover, and Birdsfoot Trefoil in Mixture with Grass (W. C. Templeton, Jr., and R. R. Hill, Jr.). . . . 48
Integration and Evaluation of Forage Production, Handling, and Utilization Systems (D. P. Knievel, E. J. Partenheimer, and W. L. Kjelgaard) 48
Effects of Wintering Brood Cows in a Pennsylvania Woodlot (L. L. Wilson, T. W. Bowersox, D. A. Devlin, and P. J. LeVan) 49
Responses of Perennial Legume Varieties to Management (W. C. Stringer and K. T. Leath). 49
Effect of Lime and Phosphorus on Legume Growth and N Fixation (G. O. Estes and D. T. Roberts) 50
Productivity and Quality of Fertilized Perennial Forages (L. E. Lanyon) 50
Hay and Silage Investigations (Milton A. Sprague). 51
Forage-Livestock Systems for Land with Soil and Site Limitations (Milton A. Sprague) 52
Soil-Plant-Environment Relationships in the Productivity and Quality of Forages (W. C. Stringer and L. A. Lanyon). 52
Effect of Magnesium Fertilization on Timothy Yield and Mineral Composition (B. S. Baker and R. L. Reid). 53
Forage Yield Determinations of Mixed Swards Using a Disk Meter (B. S. Baker, T. V. Eynden, and N. Boggess). 53
Nutrient Utilization Efficiency of Crop Species, Hybrids, and Cultivars (R. H. Fox and R. J. Morris). . . 54
Producing Dried Immature Forages as Grain Substitutes for Ruminants (R. F. Stafford and R. G. Hall). 55
Availability of Magnesium from Different Sources Under Field Conditions (V. D'Costa, R. F. Keefer, and R. N. Singh) 55

Development of Seeding Techniques and Management Systems for Feed Crops in Southwestern Pennsylvania (W. G. Downs, III). 56
Forage-Livestock Systems for Land with Soil and Site Limitations (R. C. Wakefield and J. D. Stich) . . . 56
Effect of Nutrition on Early Development of Corn (G. O. Estes). 57
Flexible Forage Production and Utilization Systems for Pennsylvania's Varied Environments (K. T. Leath and W. C. Stringer). 57
Comparison of Methods of Legume Establishment in Hill Pasture Under Rotational Grazing (W. B. Bryan). . . 58
Forage-Livestock Systems for Land with Soil and Site Limitations (A. M. Decker, R. F. Dudley, H. T. Badger, and W. E. Beers) 58
Effect of Management Factors on Alfalfa Productivity and Persistence (W. C. Stringer) 59
Evaluation of Sod-seeded Pastures Using Dairy Steers and Heifers (A. M. Decker, J. H. Vandersall, and W. E. Beers) 59
Red Clover Variety Trials (A. M. Decker and W. E. Beers) 60
Forage Production and Quality Evaluations (A. M. Decker, R. F. Dudley, and W. E. Beers) 60
Supplemental Protein for Gestating Beef Cows Fed Corn Residue (W. E. Kunkle, E. C. Leffel, and J. Buric). 60
Forage Variety Tests (W. W. Washko). 61
NE 114--Forage-Livestock Systems for Land with Soil and Site Limitations (W. B. Bryan). 62
Weed Control with Broadcast Seeded Forage Varieties of Turnips, Swedes, Rape, and Sugar and Fodder Beets (V. Ulrich and G. A. Jung) 62
Production Efficiency and Quality of Forages for Increased Use in New England (D. W. Koch, G. O. Estes, and G. W. Mueller-Warrant). 63

SECTION VII. ENGINEERING RESEARCH. 64
Processing Dried, Immature Forage as Grain Substitutes for Ruminants (R. J. Rowe) 65
Microbial Conversion of Solid Wastes in Plant Protein Recovery (R. E. Mudgett and P. L. Pellett) . . . 65
Solid-state Fermentation Processes in Plant Protein Recovery (R. E. Mudgett, P. L. Pellett, and R. Rufner) 66
Yeast Cultivation on Alfalfa Process Wastes (R. E. Mudgett). 66

SECTION VIII. NUTRITIVE EVALUATION AND UTILIZATION 67
Nutritive Value of Warm-Season Grass Hays for Beef Cattle and Sheep (R. L. Reid, G. A. Jung, and W. C. Sharp) 68
Evaluation and Use of Meadow Voles as a Bioassay of Forage Quality and Model for Ruminant Animals (R. L. Cowan, T. V. Hershberger, H. Rothenbacher, J. S. Shenk, and W. C. Templeton, Jr.) 68
Utilization of Digestible Energy in Cattle (H. F. Tyrrell, P. W. Moe, and P. J. Reynolds) 69
Sodium Bicarbonate Addition to Corn Silage Rations of Prepartum and Postpartum Dairy Cows (L. D. Muller, L. H. Kilmer, and P. J. Wangsness) 69
Brown Midrib Corn Silage for Ruminants (L. D. Muller, E. Block, and D. L. Garwood) 70
Factors Contributing to Hypomagnesemia in Lactating Angus and Angus-Charolais Cows on Pasture (D. D. Fisher, L. L. Wilson, P. J. LeVan, R. W. Scholz, and W. C. Stringer). 71
Intestinal Microorganisms and Their Contribution to Animal Nutrition (L. L. Slyter) 71
Influence of Heat and Other Processing Variables on the Utilization of Forage Nitrogen (H. K. Goering and D. R. Waldo) 72
Creep Grazing for Beef Production (E. C. Prigge and W. B. Bryan) 72
Comparison of Soybean Meal, Urea, Dehydrated Poultry Excreta (DPE), and Broiler Litter (BL) as Nitrogen Sources for Lambs (L. W. Smith). 73
Quality of Timothy Hay as Affected by Magnesium Fertilization (R. L. Reid, B. S. Baker, and G. A. Jung). 74
Studies on Allelochemical Properties of Crownvetch and Their Effects on Forage Quality (D. L. Gustine and B. G. Moyer) 74
Comparison of Winter Hay Feeding Systems for Beef Heifers (D. L. Lee, L. L. Wilson, P. J. LeVan, M. F. Cain, W. L. Kjelgaard, and P. M. Anderson) 75
Blood and Salivary Composition of Lactating Beef Cows and Mineral Utilization by Sheep on Magnesium Fertilized Spring Pasture (J. K. Thompson, R. L. Reid, and G. Mandata). 75
Energy Value of Feedstuffs of Dairy Cattle (P. W. Moe and H. F. Tyrrell). 76
Microbiological Aspects of Digestion and Use of Cellulosic Crop Residues by Ruminants (M. E. Simpson). 77
Utilization of Non-protein Nitrogen by Continuous In Vitro Cultures of Ruminal Microorganisms (G. Varga and E. C. Leffel). 77

Selenium Status of Beef Cattle and Sheep in Pennsylvania and West Virginia (Donna L. Stadtmore, R. L. Reid, and G. A. Jung). 78
Feeding Dried Immature Forages as Grain Substitutes for Ruminants (Martin R. Stokes) 79
Performance and Volatile-Fatty-Acid Production of Lambs Fed Buffers in Diets Varying in Forage: Concentrate Ratios (M. J. David and E. C. Leffel). . . . 80
Formaldehyde and Other Additives for Ensiling Forages (D. R. Waldo and H. K. Goering). 81
The BARC Forage Research Program with Sheep (G. P. Lynch). 81
Alfalfa-Corn Stover Silage for Replacement Dairy Animals (J. H. Vandersall) 82
Optimizing Intake and Digestibility of Forages (P. J. Wangsness, J. S. Shenk, H. W. Harpster, E. Keck, W. L. Kjelgaard, and W. C. Templeton, Jr.). . . 82
Optimizing Intake and Digestibility of Forages by Ruminants (J. G. Welch). 83
Morphological and Anatomical Traits in Plants Influencing Digestibility (J. B. Powell, D. Dinius, P. S. Baenziger, and J. Bond). 83
Optimizing Intake and Digestibility of Forages by Ruminants: Calcium Nutrition (J. L. Evans, Z. Lelkes, P. Zajac, D. Yoon). 84
The Effect of Using Ralgro, Stilbestrol, and Thibenzole on Gains of Yearling Steers on Pasture (L. Malkus, T. Clay, S. Godber, and D. Magione). 85
Growth and Physiological Parameters of Ruminants Grazing Different Varieties of Tall Fescue Pasture (James Bond and J. B. Powell). 85
Infrared for Evaluating Forage Quality and Nutritive Value (J. S. Shenk, M. R. Hoover, M. O. Westerhaus, W. C. Templeton, Jr., G. W. Fissel, and W. G. Lynch) 86
Productivity and Composition of Nitrogen-fertilized Grass and Grass-legume Pastures Under Grazing Conditions (D. D. Fisher, L. L. Wilson, P. J. LeVan, and W. C. Stringer) 86

SECTION IX. SILAGE AND HAY RESEARCH. 88
Use of Silage Preservatives to Reduce Storage Losses (J. B. Holter). 89

SECTION X. ENVIRONMENTAL RESEARCH. 90
Effects of Sewage Sludge on Soils and Yield of Corn and Soybeans (A. M. Decker, R. L. Chaney, and W. E. Beers) 91

Feasibility of Using Sewage Sludge for Plant and Animal Production (A. M. Decker, J. P. Davidson, R. L. Chaney, S. B. Mohanty, and R. C. Hammond). 91

LIST OF PUBLICATIONS. 92

RECIPIENTS OF GRADUATE DEGREES. 104

PREFACE

This report is intended, primarily, for use by forage research and extension personnel in Northeastern United States. Included are highlights of forage research activities at most of the agricultural experiment stations in the region and those of the Northeastern Region, Agricultural Research, Science and Education Administration, and Beltsville Agricultural Research Center, U.S. Department of Agriculture.

Appreciation is extended to the scientists and others whose contributions made the report possible. The assistance of Mrs. Teri-Anne Jordan in assembling, retyping, and preparing the report is gratefully acknowledged.

Continuing support and contributions from forage scientists of the region are solicited and encouraged to make the report as valuable as possible. We solicit continuing assistance in obtaining names of newly-arrived forage researchers, transfers, and retirees in the region to keep our records and mailing lists current. Also, suggestions concerning improvement and desirable changes will be appreciated.

William C. Templeton, Jr.
Director, U.S. Regional Pasture
Research Laboratory

AUTHOR INDEX

A

Amrine, J. W. (20)
Anderson, P. M. (75)

B

Badger, H. T. (58)
Baenziger, P. S. (83)
Baker, B. S. (53, 74)
Baker, P. B. (21)
Balasko, John A. (11)
Batra, S. W. T. (37)
Baylor, J. E. (40)
Beers, W. E. (58, 59, 60, 91)
Block, E. (70)
Bloom, J. R. (25)
Boggess, N. (53)
Bond, James (83, 85)
Bookbinder, M. G. (25)
Bowersox, T. W. (33, 35, 49)
Bryan, W. B. (31, 58, 62, 72)
Buric, J. (60)
Butler, Linda (20)
Byers, R. A. (20, 21, 22)

C

Cain, M. F. (75)
Carlson, G. E. (47)
Chaney, R. L. (91)
Chatterton, N. J. (47)
Clark, N. A. (47)
Clay, T. (85)
Cleveland, R. W. (6)
Cohen, R. P. (29)
Cowan, R. L. (68)

D

David, M. J. (80)
Davidson, J. P. (91)
D'Costa, V. (55)
Decker, A. M. (58, 59, 60, 91)
Devlin, D. A. (35, 49)
Dinius, D. (83)
Dolan, Desmond, D. (12)
Downs, W. G., III (56)
Dudley, R. F. (58, 60)

E

Elden, T. C. (8, 19)
Elgin, J. H., Jr. (4, 8, 19)
Ellis, R., Jr. (30)
Estes, G. O. (50, 57, 63)
Evans, J. L. (84)
Eynden, T. V. (53)

F

Faust, Robert M. (22)
Fick, G. W. (19, 31)
Fiori, Bart J. (12)
Fisher, D. D. (71, 86)
Fissel, G. W. (86)
Flanagan, T. R. (40)
Fox, R. H. (33, 54)
Foy, C. D. (4, 5)

G

Garwood, D. L. (70)
Godber, S. (85)
Goering, H. K. (72, 81)
Gross, C. F. (25)
Grunes, D. L. (30)
Gustine, D. L. (26, 74)

H

Hall, R. G. (55)
Hammond, R. C. (91)
Harpster, H. W. (82)
Hartwig, [illegible] L. (40, 45)
Helgesen, R. G. (19)
Hershberger, T. V. (68)
Hill, R. R., Jr. (7, 24, 48)
Holter, J. B. (89)
Holyoke, V. H. (40)
Hoover, M. R. (86)
Hunt, J. F. (40)

I

Ilnicki, R. D. (40)

J

Jones, G. (31)
Jung, G. A. (62, 68, 74, 78)
Justin, J. R. (40)

K

Keck, E. (82)
Keefer, R. F. (55)
Kendall, W. A. (22, 35, 68)
Kilmer, L. H. (69)
Kjelgaard, W. L. (33, 48, 75, 82)
Knievel, D. P. (48)
Koch, D. W. (34, 44, 63)
Kunkle, W. E. (60)

L

Lanyon, L. E. (50, 52)
Leath, K. T. (24, 25, 49, 57)
Lee, D. L. (75)
Leffel, E. C. (60, 77, 80)
Lelkes, Z. (84)
LeVan, P. J. (49, 71, 75, 86)
Linscott, D. L. (37, 38, 40)
Long, T. A. (3)
Lowe, C. C. (3, 6, 7, 9, 19)
Lucas, M. A. (35)
Lukezic, F. L. (25)
Lynch, G. P. (81)
Lynch, W. G. (86)

M

Magione, D. (85)
Malkus, L. (85)
Mandata, G. (75)
Mangan, R. L. (21)
Materu, M. B. (31)
McMurtrey, J. E., III (4, 8)
McNemar, J. H. (47)
Meade, J. A. (40)
Millar, R. L. (26)
Milligan, R. A. (31)
Mitchell, J. B. (40)
Mitchell, W. H. (40)
Moe, P. W. (69, 76)
Mohanty, S. B. (91)
Morris, R. J. (54)
Moyer, B. G. (26, 74)
Mudgett, R. E. (65, 66)
Mueller-Warrant, G. W. (44, 63)
Muller, L. D. (69, 70)
Murphy, R. P. (3, 6, 7, 9)
Murray, J. J. (5, 21, 31)

O

O'Brien, Patrick M. (11)
O'Neill, N. R. (10)
Ostazeski, S. A. (8)
Owens, L. D. (32)

P

Parochetti, J. V. (40)
Partenheimer, E. J. (33, 48)
Pellett, P. L. (65, 66)
Peoples, T. R. (34)
Peters, R. A. (40)
Plummer, J. A. (22)
Powell, J. B. (5, 10, 83, 85)
Priddy, W. A. (24)
Prigge, E. C. (72)

R

Ratcliffe, R. H. (21)
Rayburn, E. B. (38)
Reed, H. E. (20)
Reid, R. L. (53, 68, 74, 75, 78)
Reynolds, P. J. (69)
Risius, M. L. (3, 6)
Roberts, D. T. (50)
Rothenbacher, H. (68)
Rowe, R. J. (65)
Rufner, R. (66)

S

Schaaf, H. M. (2, 37)
Scholz, R. W. (71)
Seaney, R. R. (40)
Sharp, W. C. (68)
Shenk, J. S. (2, 6, 10, 68, 82, 86)
Sherring, William R. (12)
Sherwood, R. T. (5)
Shubert, O. E. (40)
Simpson, M. E. (77)
Singh, R. N. (55)
Sloger, C. (32)
Slyter, L. L. (71)

Smith, L. W. (73)
Sniffen, C. J. (31)
Sperow, C. B., Jr. (40)
Sprague, Milton A. (34, 51, 52)
Stadtmore, Donna L. (78)
Stafford, R. F. (55)
Stich, J. D. (56)
Stokes, Martin R. (79)
Stringer, W. C. (33, 35, 49, 52, 57, 59, 71, 86)
Sumberg, J. E. (6)

T

Taylor, L. C. (31)
Templeton, W. C., Jr. (21, 35, 48, 68, 82, 86)
Thayne, William V. (11)
Thompson, J. K. (75)
Tyrrell, H. F. (69, 76)

U

Ulrich, V. (62)

V

Vandersall, J. H. (59, 82)
Varga, G. (77)
Vaughan, R. H. (37)
Vengris, J. (40)
Vough, L. R. (47)

W

Wakefield, R. C. (40, 56)
Waldo, D. R. (72, 81)
Wangsness, P. J. (69, 82)
Washko, W. W. (61)
Weaver, J. E. (20)
Welch, J. G. (29, 83)
Westerhaus, M. O. (86)
Wilson, L. L. (33, 35, 49, 71, 75, 86)
Wood, G. M. (29)

Y

Yoon, D. (84)
Young, B. A. (5)

Z

Zajac, P. (84)
Zeiders, K. E. (24, 25, 27)

ROSTER OF RESEARCH AND EXTENSION WORKERS IN NORTHEASTERN UNITED STATES WITH FORAGE CROPS AND GRASSLANDS ORIENTATION

Name	Field of Interest	Department
UNIVERSITY OF CONNECTICUT, Storrs, 06268		
Allinson, D. W.	Forage Management	Plant Science
Cowan, W. A.	Animal Nutrition	Animal Industries
Dest, W. M.	Weed & Turf Invest.	Plant Science
Griffin, G. F.	Soil Fertility	Plant Science
Peters, R. A.	Weed Investigations	Plant Science
Washko, W. W.	Forage Management	Plant Science
Wengel, R. W.	Soil Physics	Plant Science
UNIVERSITY OF DELAWARE, Newark, 19711		
Carroll, Robert B.	Plant Pathology	Plant Science
Fowler, R. E.	Beef Cattle Nutrition	Anim. Sci. & Agric. Biochemistry
Haenlein, G. F. W.	Nutritive Evaluation	Anim. Sci. & Agric. Biochemistry
Jones, E. R.	Forage Management	Delaware State College
Mitchell, W. H.	Forage Management	Plant Science
Reitnour, C. M.	Equine Physiology	Anim. Sci. & Agric. Biochemistry
UNIVERSITY OF MAINE, Orono, 04473		
Forsythe, H. Y., Jr.	Forage Insects	Entomology
Hall, R. G.	Agronomy	Plant & Soil Sciences
Holyoke, V. H.	Silage Corn Manag.	Plant & Soil Sciences
Rowe, R. J.	Engr. Harvesting	Agric. Engineering
Stafford, R. F.	Agronomy	Plant & Soil Sciences
Stokes, M. R.	Rumin Nutrition	Anim. & Vet. Sciences
UNIVERSITY OF MARYLAND, College Park, 20742		
Decker, A. M., Jr.	Forage Management	Agronomy
Kunkle, W. E.	Animal Nutrition	Animal Science
Leffel, E. C.	Animal Nutrition	Animal Science
Vandersall, J. H.	Dairy Nutrition	Dairy Science
Vough, L. R.	Forage Crops	Agronomy

Name	Field of Interest	Department
UNIVERSITY OF MASSACHUSETTS, Amherst, 01002		
Fenner, Heinrich	Animal Nutrition	Vet. & Anim. Sciences
Mudgett, R.	Food & Agric. Eng.	Engineering (Food & Agric.)
Whitney, L. F.	Agric. Engineering	Engineering (Food & Agric.)
UNIVERSITY OF NEW HAMPSHIRE, Curham, 03824		
Byers, G. L.	Agric. Engineering	Inst. of Natural & Env. Resources
Dunn, G. M.	Forage Genetics	Plant Science
Estes, G. O.	Forage Nutrition	Plant Science
Fairchild, T. P.	Dairy Breeding	Animal Sciences
Frick, G. E.	Agric. Economics	Inst. of Natural & Env. Resources
Holter, J. B.	Dairy Nutrition	Animal Sciences
Koch, D. W.	Forage Plant Phys.	Plant Science
Mitchell, J. B.	Forage Management	Plant Science
Peirce, L. C.	Genet. Hort. Crops	Plant Science
RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY, New Brunswick, 08903		
Duell, R. W.	Highway Vegetation	Soils & Crops
Evans, J. L.	Animal Nutrition	Animal Science
Flannery, R. L.	Soils	Soils & Crops
Halisky, P. M.	Plant Pathology	Plant Biology
Ilnicki, R. D.	Weed Control	Soils & Crops
Justin, J. R.	Farm Crops	Soils & Crops
Mears, D. R.	Agric. Engineering	Eng. (Biology & Agric.)
Race, S. R., Jr.	Forage Insects	Ent. & Econ. Zoology
Singley, M. E.	Engineering Util.	Eng. (Biology & Agric.)
Sprague, M. A.	Manag. & Preservation	Soils & Crops
CORNELL UNIVERSITY (New York), Ithaca, 14853		
Campbell, J. K.	Agric. Engineering	Engineering (Agric.)
Duke, W. B.	Weed Control	Agronomy
Fick, G. W.	Forage Phys. & Manag.	Agronomy
Helgesen, R. G.	Entomology	Entomology
Kubota, Joe	Soil Class.	Agronomy
Lowe, C. C.	Genetics & Breeding	Plant Breeding & Biom.
Millar, R. L.	Forage Diseases	Plant Pathology
Murphy, R. P.	Genetics & Breeding	Plant Breeding & Biom.
Reid, J. T.	Animal Nutrition	Animal Science
Seaney, R. R.	Forage Management	Agronomy
Van Soest, P. J.	Animal Nutrition	Animal Science

Name	Field of Interest	Department
U.S. PLANT, SOIL, AND NUTRITION LABORATORY, U.S. Department of Agriculture, Science and Education Administration, Agricultural Research, Northeastern Region, North Atlantic Area, Tower Road, Ithaca, New York, 14850		
Grunes, D. L.	Soils & Plant Nutr.	Agronomy (USDA-SEA)
Linscott, D. L.	Weed Control	Agronomy (USDA-SEA)
Schaaf, H. M.	Genetics & Breeding	Plant Breeding & Biom. (USDA-SEA)
NEW YORK STATE AGRICULTURAL EXPERIMENT STATION, Geneva, 14456		
Dolan, D. D.	Plant Introduction	Seed & Veg. Sciences (USDA-SEA)
Fiori, B. J.	Entomology	Entomology (USDA-SEA)
Sherring, W. R.	Seed Technology	Seed Investigations
THE PENNSYLVANIA STATE UNIVERSITY, University Park, 16802		
Ace, D. L.	Dairy Extension	Dairy & Animal Science
Adams, R. S.	Dairy Extension	Dairy & Animal Science
Bartlett, H. D.	Agric. Engineering	Agric. Engineering
Baylor, J. E.	Pasture & Forage Crops	Agronomy Extension
Bloom, J. R.	Nematode Control	Plant Pathology
Buckalew, J. M.	Dairy Science	Dairy & Animal Science
Burdette, L. A.	Anim. Nutrition Ext.	Dairy & Animal Science
Cash, E. H.	Animal Nutrition	Dairy & Animal Science
Cleveland, R. W.	Genetics & Breeding	Agronomy
Cowan, R. L.	Animal Nutrition	Dairy & Animal Science
Downs, W. G., III	Forage Management	Agronomy (P.O. Rector)
Dum, S. A.	Farm Manag. Ext.	Economics
Fox, R. H.	Soil Fertility	Agronomy
Hartwig, N. L.	Weed Control	Agronomy
Hershberger, T. V.	Animal Nutrition	Dairy & Animal Science
Hower, A. A., Jr.	Forage Insects	Entomology
Johnson, M. W.	Corn Breeding	Agronomy
Kesler, E. M.	Dairy Science	Dairy & Animal Science
Kjelgaard, W. L.	Agric. Engineering	Agric. Engineering
Knievel, D. P.	Forage Physiology	Agronomy
Lanyon, L. E.	Soil Fertility	Agronomy
Long, T. A.	Animal Nutrition	Dairy & Animal Science
Lukezic, F. L.	Forage Pathology	Plant Pathology
McKee, G. W.	Crop Economics	Agronomy
Merritt, T. L.	Animal Science	Dairy & Animal Science
Partenheimer, E. J.	Agric. Economics	Agric. Econ. & Rural Soc.
Risius, M. L.	Genetics & Breeding	Agronomy
Shenk, J. S.	Forage Grass Breeding	Agronomy
Starling, J. L.	Genetics & Breeding	Agronomy
Stringer, W. C.	Forage Management	Agronomy

Name	Field of Interest	Department
THE PENNSYLVANIA STATE UNIVERSITY (Continued)		
Wangsness, P. J.	Animal Nutrition	Dairy & Animal Science
Wilson, L. L.	Animal Science	Dairy & Animal Science
Yendol, W. G.	Insect Control	Entomology
UNIVERSITY OF RHODE ISLAND, Kingston, 02881		
Henderson, B. W., Jr.	Animal Nutrition	Animal Science
Wakefield, R. C.	Management	Plant & Soil Sciences
UNIVERSITY OF VERMONT, Burlington, 05401		
Gotlieb, A. R.	Plant Pathology	Botany
MacCollom, G. B.	Entomology	Entomology
Smith, A. M.	Animal Nutrition	Animal Sciences
Welch, J. G.	Nutritional Value	Animal Sciences
Wood, G. M.	Forage & Turf Manag.	Plant & Soil Sciences
WEST VIRGINIA UNIVERSITY, Morgantown, 26506		
Anderson, G. C.	Animal Nutrition	Anim. & Vet. Sciences
Baker, B. A.	Forage Management	Allegheny Highlands Project (Elkins, WV)
Balasko, J. A.	Forage Physiology	Plant Sciences
Bennett, O. L.	Forage Management	Plant Sciences (USDA-SEA)
Butler, Linda	Entomology	Plant Sciences
Diener, R. G.	Agric. Engineering	Resource Management
Elliott, E. S.	Root Diseases	Plant Sciences
Horvath, D. J.	Animal Nutrition	Anim. & Vet. Sciences
Keefer, R. F.	Soil Fertility	Plant Sciences
Reid, R. L.	Animal Nutrition	Anim. & Vet. Sciences
Thomas, R. O.	Dairy Nutrition	Anim. & Vet. Sciences
Toben, G. E.	Agric. Economics	Resource Management
Ulrich, V.	Plant Breeding	Plant Sciences
BELTSVILLE AGRICULTURAL RESEARCH CENTER, U.S. Department of Agriculture, Science and Education Administration, Agricultural Research, Northeastern Region, Beltsville, Maryland, 20705		
Adams, J. R.	Entomology	Insect Pathology Lab
Barnes, R. F	Forage and Range	National Program Staff
Bond, J.	Animal Science	Ruminant Nutrition Lab
Carlson, G. E.	Agronomy	Light & Plant Growth Lab
Calvert, C. C.	Animal Science	Feed Energy Cons. Lab

Name	Field of Interest	Department
BELTSVILLE AGRICULTURAL RESEARCH CENTER (Continued)		
Chatterton, N. J.	Plant Physiology	Light & Plant Growth Lab
Coulson, J. R.	Entomology	Benef. Insect Intro. Lab
Dinius, D. A.	Animal Science	Ruminant Nutrition Lab
Dudley, R. F.	Agric. Engineering	Agric. Engineering
Elgin, J. H., Jr.	Agronomy	Field Crops Lab
Faust, R. M.	Entomology	Insect Pathology Lab
Feldmesser, J.	Zoology	Nematology Lab
Foy, C. D.	Soil Science	Plant Stress Lab
Goering, H. K.	Animal Science	Ruminant Nutrition Lab
Heimpel, A. M.	Entomology	Insect Pathology Lab
Hill, K. R.	Chemistry	Analytical Chem. Lab
Hodges, R. W.	Entomology	Systematic Entom. Lab
Hooven, N. W., Jr.	Animal Science	Animal Operations
Howell, R. K.	Plant Pathology	Plant Stress Lab
Keys, J. E., Jr.	Animal Science	Feed Energy Cons. Lab
Kulik, M. M.	Plant Pathology	Seed Quality Lab
Lentz, P. L.	Botany	Mycology Lab
Louloudes, S. J.	Entomology	Insect Pathology Lab
Lynch, G. P.	Animal Science	Ruminant Nutrition Lab
Moe, P. W.	Animal Science	Ruminant Nutrition Lab
Murray, J. J.	Agronomy	Field Crops Lab
Norris, Karl	Laboratory Chief	Instrumentation Research
Oakes, A. J.	Agronomy	Germplasm Resources Lab
Ostazeski, S. A.	Plant Pathology	Field Crops Lab
Owens, L. D.	Plant Physiology	Plant Nutrition Lab
Pearson, R. E.	Animal Genetics	Genetics & Manag. Lab
Powell, J. B.	Genetics	Field Crops Lab
Ratcliffe, R. H.	Entomology	Field Crops Lab
Redfern, R. E.	Entomology	Biol. Eval. of Chemicals
Reynolds, P. J.	Animal Science	Ruminant Nutrition Lab
Rumsey, T. S.	Animal Science	Ruminant Nutrition Lab
Schechter, M. S.	Chemistry	Chem. & Biophys. Cons.
Schroder, R. F.	Entomology	Benef. Insect Intro. Lab
Simpson, M. E.	Plant Pathology	Feed Energy Cons. Lab
Slyter, L. L.	Chemistry	Feed Energy Cons. Lab
Smith, L. W.	Animal Science	Biol. Waste Manag. Lab
Terrell, E. E.	Botany	Plant Taxonomy Lab
Toole, V. K.	Plant Physiology	Seed Quality Lab
Tyrrell, H. F.	Animal Science	Ruminant Nutrition Lab
Waldo, D. R.	Animal Science	Ruminant Nutrition Lab
Wheeler, W. E.	Animal Science	Ruminant Nutrition Lab
White, G. A.	Laboratory Chief	Germplasm Resources Lab
Yaklich, R. W.	Plant Physiology	Seed Quality Lab

Name	Field of Interest	Department

U.S. REGIONAL PASTURE RESEARCH LABORATORY, U.S. Department of Agriculture, Science and Education Administration, Agricultural Research, Northeastern Region, North Atlantic Area, University Park, Pennsylvania, 16802

Templeton, W. C., Jr.	Forage Crops Ecology	Laboratory Director
Berg, C. C.	Genetics (Grasses)	
Byers, R. A.	Forage Insects	
Fissel, G. W.	Chemistry	
Gross, C. F.	Soil Fertility	
Gustine, D. L.	Biochemistry	
Hill, R. R., Jr.	Genetics (Alfalfa)	
Jung, G. A.	Forage Management	
Kendall, W. A.	Plant Physiology	
Leath, K. T.	Pathology (Legumes)	
Sherwood, R. T.	Pathology (Grasses)	
Zeiders, K. E.	Plant Pathology	

SECTION I

BREEDING, GENETICS, AND PLANT INTRODUCTION RESEARCH

Title: Forage Breeding and Quality

Leader: J. S. Shenk (The Pennsylvania State University)

A comprehensive breeding program to improve the yield and quality of orchardgrass was continued with four source populations (A, B, C, D) of over 10,000 plants. Each population has been reduced to 100-200 plants, divided into maturity groups and crossed in open pollinated groups of 50-100 plants. Yield, quality, and Dairy Herd Simulation values were obtained from progeny of 150 plants of population C. Progeny of 100 plants from population D have been established in field plots (1 x 1.2 m) using a triple lattice design. These plots will be harvested next year.

A new plot harvester has been designed and tested which allows one person to harvest, weigh, and sub-sample each plot. A 20 hp Gravely tractor was attached to a custom designed hydraulic powered front mounted flail harvester. The electronic weighing apparatus was supplied by Campbell Scientific of Logan, Utah. This electronic balance provides more accurate weighings than our previously used spring scales. Plot harvesting can now be accomplished with one person in almost the same time as was required by three persons.

Title: Improvement of Birdsfoot Trefoil by Breeding

Leader: H. M. Schaaf (U.S. Plant, Soil, and Nutrition Laboratory)

Two genotypes with virtual immunity to Stemphylium loti were previously isolated in Lotus tenuis (2N-12); no useful level of resistance to the fungus was found in L. corniculatus (2N=24). Both of the resistant diploids were sterile following inter- and intra-specific crossing by hand, but they each produced seed when grown in the field with fertile diploids and tetraploids. None of the offspring obtained by open pollination showed significant resistance to S. loti. While most of the OP's are diploid, one is triploid and another is tetraploid, both of which are fertile in hand pollinations. On the basis of earlier findings, the populations in 3 trefoil breeding nurseries were selected for vegetative vigor in 1978. Polycross seed of various groups of these selections is being produced. In tests on inbreeding effects on the fertility and vegetative vigor of trefoil in dense stands, seed yields of the OP progenies of BC_1 plants averaged 52% lower than those of the OP progenies of their F_1 counterparts, yet in total dry matter yield the BC_1's averaged only 6% lower than the F_1's.

Title: Breeding Crownvetch for Forage and Slope Stabilization Usage

Leaders: T. A. Long and M. L. Risius (The Pennsylvania State University)

Crownvetch plants selected from breeding nurseries have been intercrossed using honey bees in a screen cage in a greenhouse during the winter months. A study of longevity of pollen carried by bees was undertaken using the white flower trait as a genetic marker. After the bees were exposed to pink-flowered plants for a two week period, individual plants of a single white flower genotype were placed in the cage at 24-hour intervals. In the first experiment, the proportion of pink-flowered plants produced from bee pollinations during the first 24-hour period was 93 percent and decreased to 23 percent by the fourth successive 24-hour period. In a second experiment the proportion of pink-flowered plants was 94 percent for the first 24-hour period and decreased to 79 percent by the fourth successive 24-hour period. Viable pollen from pink-flowered plants was being carried by honey bees for at least 96 hours. Thus adequate pollen distribution among groups of crownvetch plants seems to be assured under these conditions. However, the time required between groups of crownvetch plants to prevent carryover of viable pollen by honey bees between groups of plants remains to be determined.

Plants derived from Chemung crownvetch and selected for early spring growth, rapid recovery following harvest, and other agronomically useful traits were intercrossed in the greenhouse to begin another selection cycle.

Title: Breeding and Cytogenetic Investigations and Improvement of Cool-Season Perennial Forage Species

Leaders: C. C. Lowe and R. P. Murphy (Cornell University)

Selection programs are in progress for alfalfa for forage quality, pest resistance, and growth characters with possible consequence to inherent yield potential. Phytophthora resistance is being added to Iroquois, a direct derivative of the Narragansett variety which was known for its adaptation to marginal production environments. Strains originating from this effort have already been shown to be superior in comparative tests where Phytophthora damage has been induced by excessive irrigation. A series of alfalfa trials is now being conducted in New York to assess occurrence and significance of Phytophthora damage in growing environments with marginal drainage. These trials have so far failed to demonstrate any instance of economic advantage for the Phytophthora resistance levels in currently available varieties. Our best interpretation is that there are probably multiple hazards to alfalfa production in growing areas where excess water is a problem and Phytophthora damage

is only one of them. Combined with other features it could be a help but there is no current evidence that it alone has extended successful alfalfa adaptation to poorly drained production areas as implied by some advertising claims.

Selection is also in progress for tolerance to the potato leafhopper and the alfalfa blotch leafminer. There is considerable doubt whether the miner does significantly influence economic value of alfalfa forage. However, the leafhopper definitely does and breeding progress for insect tolerance seems to be very slow relative to progress for disease resistance.

Emphasis on different growth types has centered on spreading crowns, multifoliolate leaves, and shortening of the required regrowth interval. A wide-crowned synthetic has been produced for testing. It could have significance for maintaining or thickening stands. The multifoliolate character has been demonstrated to affect alfalfa leaf content, but effects on quality constituents of the forage are less conclusive. A problem with seed production on this material has apparently been corrected by selection.

Title: Breeding Alfalfa for Tolerance to Aluminum Toxicity in Acid Soils

Leaders: J. H. Elgin, Jr., J. E. McMurtrey, III, and C. D. Foy (Beltsville Agricultural Research Center)

Field performance evaluations of our nutrient-culture, laboratory-developed, Al-tolerant alfalfa were initiated in the spring of 1978 on limed and unlimed Al-toxic acid clay soils (pH 4.0) near Orange, Va. During the year of establishment, little evidence of advantage from the Al-tolerant strain over the base population Arc and the cultivars Saranac AR and Williamsburg was observed. In plots where no lime was applied, essentially no alfalfa was established. Where lime was applied, good establishment was obtained with all entries. First-year yields will be taken to determine if a yield advantage attributable to deeper root penetration of the Al-tolerant line can be shown during summer droughts. In addition, similar comparative field studies were established in the fall of 1978 near Largo, Md., on limed and unlimed acidic (pH 4.2) sandy loam soil with low to moderate levels of available Al. Uniform emergence from all entries was obtained, but subsequent growth on the unlimed plots was very slow and most of the seedlings were lost during the winter. As in the Virginia study, yields will be taken from these plots to determine if a yield advantage due to deeper root penetration of the Al-tolerant line can be shown.

Title: Regulation of Apomixis in Forage Grasses

Leaders: R. T. Sherwood and B. A. Young (U.S. Regional Pasture Research Laboratory and The Pennsylvania State University)

We confirmed the validity of a technique for classifying embryo-sac type in buffelgrass pistils by using interference contrast microscopy to examine cleared pistils. Seventy pistils were classified by clearing and then were sectioned and reexamined. The clearing technique equaled sectioning in accuracy and was 10 X faster. We demonstrated the occurrence of facultative apomixis in buffelgrass. More than 80% of the pistils of line 18-35 were aposporously apomictic, but some pistils had single polygonous type sexual embryo sacs, and some had both aposporic and sexual sacs. The frequency of single sexual and mixed embryo sacs varied among planting and harvests. Line 18-35 was progeny tested: 40 of 1,300 progeny were offtype. Preliminary chromosome counts of five offtype progeny approximated those of the tetraploid parent. Some offtype progeny produced mostly, or exclusively, sexual embryo-sacs; others produced principally aposporic embryo sacs. Approximately 30 pistils were classified for type of embryo-sac development in 180 S_1 progeny plants of obligately sexual plant B-1s. Open-pollinated (presumably self-pollinated) progeny of facultatively apomictic line 18-35 were also classified. The progeny appeared to segregate into three classes--obligate sexual, obligate apomictic, and facultative apomictic. Genetic models are being developed to explain the ratios obtained. Attempts were made to alter the proportion of sexual embryo sacs in facultatively apomictic line 18-35 by treating young inflorescences with plant growth regulators including gibberellin, indole acetic acid, 2,4,-D, naphthylene acetic acid, and ethrel, or with extracts from inflorescences of sexual plants. Increases in frequency of sexual sacs occurred in certain of the inflorescences treated with gibberellins. Stage of inflorescence development at the time of treatment influenced frequency of occurrence of sexual sacs.

Title: Breeding Tall Fescue for Tolerance to Acid Soil Conditions

Leaders: J. J. Murray, J. B. Powell, and C. D. Foy (Beltsville Agricultural Research Center)

The objective of this project is to develop germplasm of tall fescue with greater tolerance to acid soil conditions. Acid-soil-tolerant cultivars should be deeper rooted than currently available types, thus performing better under conditions of lower fertility and drought stress.

Two recurrent selection methods for tolerance are being evaluated: 1) relative top yields of seedlings (45-day growth) in Tatum soil (pH 4.2)

and 2) relative root production of vegetative cuttings in Tatum soil. Polycross progeny from clones selected for tolerance based on relative top yields yielded 24% and 4% more vegetation when grown for 36 days in Tatum soil at pH 4.2 and 5.6, respectively, than that of the base populations. Preliminary results indicate that selection for tolerance based on vegetative rooting and seedling growth may be based on different traits.

Title: Improvement of Forage Quality in Alfalfa by Breeding

Leaders: C. C. Lowe, R. P. Murphy, and J. E. Sumberg (Cornell University)

Five diverse source populations of alfalfa are being used to increase protein and lower fiber content through selection based on quality assays of dried forage samples. The ADF technique is being used for fiber analysis and the Udy dye-binding procedure for protein. Out of approximately 30,000 plants in field source nurseries, 4361 were chosen for quality analyses selections in 1978. This initial screening for agronomic desirability is essential to achieve manageable numbers.

Forage samples were collected in two growth periods for selected plants and assayed in a two step process first for protein and then for fiber. Best survivors will be crossed to produce source populations for another cycle of selection. A wider range of quality values has been observed in this first cycle for populations of diverse origin and new species crosses than for control populations out of existing varieties.

Title: Breeding Red Clover and Alfalfa (Project PENO 2290)

Leaders: R. W. Cleveland, M. L. Risius, and J. S. Shenk (The Pennsylvania State University)

Breeding red clover for resistance to anthracnose was continued. Previously developed populations were evaluated. USDA-SEA and Penn State personnel cooperated in inoculation and evaluation for southern anthracnose resistance. Plants were put through two disease treatments and selections made. They will be intercrossed. Northern anthracnose resistance is also an objective of this work and this pathogen will be used in the next evaluations.

Final selections were made on old creeping rooted (CR) alfalfa field populations and the plants were established in the greenhouse for seed production. Yield trials of CR materials indicate that yields are probably not equal to those of standard varieties, but CR types might be suitable for different purposes than standard varieties. Future work with these alfalfas will characterize them for use in various ways.

Performance of alfalfa and red clover varieties was studied in trials established in past years at two Pennsylvania locations and new trials were planted. Notable results of these trials were: 1) alfalfa varieties resistant to anthracnose were superior when grown in our trial location in southeastern Pennsylvania; however, this resistance was not very important in the central part of the state; 2) red clover variety trials that included Pennscott showed this variety to be inferior. Pennscott is no longer recommended for use in Pennsylvania.

Title: New Polyploid Breeding Populations in Alfalfa for Improvement of Yield and Nutritive Value

Leaders: R. P. Murphy and C. C. Lowe (Cornell University)

New breeding materials in alfalfa are being developed from previously unused species. Several diploid species are being doubled for crossing with existing cultivated tetraploid alfalfas and hexaploid (2n = 6x =48) alfalfas are being produced by colchicine treatment of (2x X 4x) triploids. Chromosome numbers of cross progeny are being checked by cytological analysis. For 6x amphiploids, about half have been found to carry the 2n = 48 euploid number. The other plants range from 2n = 34 to 2n = 52 in number. Genetic stability and adequate fertility are the major problems in use of the hexaploid forms. A diallel study of 10 amphiploids showed good pollen production with variance in self-fertility ranging from 0 to .10 seeds per flower pollinated and cross fertility ranging from .33 to .93 seeds. New tetraploid hybrid populations trace to colchicine doubled sources of M. caerulea and M. falcata.

Title: Selection for Lignin and Phosphorus Concentration in Alfalfa

Leader: R. R. Hill, Jr. (U.S. Regional Pasture Research Laboratory)

Seeds of sixty full-sib families were produced by hand pollination on plants randomly selected from Beltsville 2-An4 alfalfa germplasm. The families were seeded in small row-plots at the Rock Springs Research Center in the spring of 1977. Yield and concentrations of lignin and phosphorus were determined on first harvest forage for the 1978 growing season.

The average P concentration of all families was 0.37%. The six families with highest P concentration (mean = 0.404%) and the six with lowest P concentration (mean = 0.307%) were selected for an addition cycle of divergent selection. The high-P selections tended to have lower yields, greater concentrations of K, Ca, and Mg, and a lower Ca/P ratio than did the low-P selections.

Lignin concentration of first cut forage averaged 9.90% over all families. Similar selections were made for lignin concentration, where high families averaged 10.87% and low families averaged 8.93%. The high lignin selections generally had greater yields and lower mineral concentrations than did the low-lignin selections. Other in vitro measures of forage quality (protein, ADF, NDF, cellulose, and IVDMD) indicated lower forage quality for the high lignin families.

Seed production for a second cycle of selection in four populations (high-P, low-P, high-lignin, low-lignin) was initiated on the selected plants in the spring of 1979.

Title: Breeding Alfalfa for Disease and Insect Resistance

Leaders: J. H. Elgin, Jr., J. E. McMurtrey, III, S. A. Ostazeski, and T. C. Elden (Beltsville Agricultural Research Center)

Third-cycle field screening of Arc and Saranac AR for Fusarium wilt resistance, caused by Fusarium oxysporum, was completed. Evaluations of the wilt resistance in cycle 2 indicated a level of 85 and 81% resistant plants has been attained in the Arc and Saranac AR populations, respectively.

Two new disease nurseries were established in 1978. A field nursery for screening for resistance to Mycoleptodiscus terrestris was established. Selections will be made in 1979 or 1980. In addition, a nursery containing 14 European Verticillium wilt-resistant cultivars was planted. Selection of plants from those cultivars best adapted to eastern U.S. will form the base for a new Verticillium wilt-resistant germplasm pool.

A 3-year field study of anthracnose-resistant and -susceptible companion strains has been completed at 23 U.S. locations. A significant yield advantage due to anthracnose resistance was found for 15 locations. Those locations where no advantage was found were mostly in northern U.S.

Procedures were developed and laboratory screening for potato leafhopper resistance was started. A population developed from two Peruvian plant introductions (247789 and 247790) demonstrated significant field resistance and also appeared to have higher than average resistance in laboratory tests.

Title: Breeding Cool-Season Forage Species for Improved Feeding Value and Productivity

Leaders: C. C. Lowe and R. P. Murphy (Cornell University)

A series of different studies has evolved the following sequential procedure in breeding for improved forage quality in alfalfa:

(1) Preliminary screening of source populations for agronomic desirability.

(2) Multiple growth-cycle sampling of screened plants for quality selection.

(3) Protein-concentration assay by the Udy dye-binding technique on forage samples for initial growth.

(4) Fiber-concentration assay by ADF procedure on bulked samples from two harvests for the plants selected by protein content assay.

(5) Crossing of survivors for additional selection cycles.

This system is based on previous experience with speed, accuracy, and costs of different quality-assay techniques; relative size of errors associated with plant sampling and lab techniques; and the size and nature of genetic variation for various quality characteristics in alfalfa. Time requirements and assay costs restrict numbers and limit quality selection to genotypes reasonably suitable to agronomic use. Multiple sampling is essential to reflect quality differences over the total growing season. The plan allows sample numbers to be scaled to available resources and facilities and integration of quality selection with other breeding objectives.

Results of an extensive study on alfalfa yield and quality with adapted varieties representing different alfalfa growth types show the introduction and use of Flamande type alfalfa has increased inherent yield potential with very negligible effects on average forage quality. Yield per acre differences for forage-quality constituents were found to be due almost entirely to variety differences in dry-matter-yield potential. It was found, however, that the productivity advantage decreased as production pressure was increased from three harvests per season to four. Specific selection for tolerance to shortened harvest intervals is needed for adaptation to more intensive management.

Current selection in timothy recognizes that this grass is used in combination with alfalfa in about 60% of the alfalfa seedings in the Northeast. Harvest management of these is entirely predicated on the alfalfa fraction. As the initial harvest date is moved toward the recommended period of early June, it means even the earliest timothy is

being harvested up to two weeks prior to anthesis. Development of an earlier type of timothy particularly adapted for this large fraction of total use appears to be in order. Seed is currently being produced on a series of new synthetics of this type.

Title: Forage Grass Breeding, Genetics, and Cytology

Leaders: J. B. Powell and N. R. O'Neill (Beltsville Agricultural Research Center)

We received the research collection of interspecific hybrids among four species of Dactylis glomerata from David L. Timothy of North Carolina State University. The collection is represented by more than 2,000 crosses of mostly diploid forms of D. glomerata of unknown economic potential. This collection, along with new plant introductions from the Soviet Union collected by Douglas R. Dewey, USDA, SEA, Logan, Utah, provides significant new germplasm for breeding orchardgrass in the United States. Detailed disease notes, vigor ratings, and maturity groups are being recorded on this germplasm. Additional germplasm of Dactylis is being obtained from an international exchange of germplasm with Japan. It is hoped that better persistence, improved hardiness, and higher quality traits will be incorporated into commercial lines of orchardgrass.

Title: Forage Breeding

Leader: J. S. Shenk (The Pennsylvania State University)

Forage samples from breeding experiments are being analyzed by the Infrared Spectro-computer system (IRSCS). At least 50 forage samples are selected from each breeding experiment to be analyzed by wet chemistry for protein, IVDMD, and NDF. These samples are used to calibrate the instrument for that particular experiment. The remaining samples are then analyzed by IRSCS.

This year, 1,500 samples were harvested for the orchardgrass breeding project. To obtain the three wet chemistry values for each sample would have required approximately 900 hours of lab work, whereas the combined wet chemistry and IRSCS required only 125 hours lab time. This represents an 86 percent reduction in time and associated labor.

Two companies are manufacturing IRSCS. They are Lemont Scientific of State College, Pennsylvania, and Neotec of Silver Spring, Maryland. Both of these systems operate with the software developed by our P.S.U/ SEA-AR infrared project.

Title: Genetic Variation for Nonstructural Carbohydrate Concentration in Tall Fescue (*Festuca arundinacea* Schreb.)

Leaders: John A. Balasko, William V. Thayne, and Patrick M. O'Brien (West Virginia University)

Production from livestock grazing tall fescue forage in late spring and summer has been poor. Until summer quality of this species is improved, its full potential as a forage crop will not be realized. The objectives of this research are to measure genetic and environmental effects and the interaction of the two on nonstructural carbohydrate concentration in tall fescue forage and to identify germplasm with high nonstructural carbohydrate concentration. Tall fescue germplasm has been vegetatively propagated in several environments within an experimental design that will allow estimates of genetic and environmental variance.

In initial work on clones within a source nursery, clones of 47 PI numbers and five varieties of tall fescue cut in fall of 1977 and in late June and early August of 1978 were analyzed for water soluble carbohydrate (WSC) concentration. The fall harvest in 1977 consisted of forage accumulated from planting in late May or early June until September or October, and the June and August harvests in 1978 were of regrowth forage. Mean WSC concentrations of the 52 accessions (approximately 19 clones of each accession were analyzed) ranged from 6.07 to 11.86% in fall of 1977, from 3.26 to 10.38% in June of 1978, and from 2.25 to 9.04% in August of 1978. At the three cutting dates, mean WSC concentrations of the variety Kenhy were consistently highest. In fall of 1977, WSC concentrations in Kenhy clones ranged from 7.23 to 20.78, in June of 1978 from 3.09 to 17.14, and in August of 1978 from 3.25 to 17.07. Among the three cutting dates, WSC concentrations of Kenhy clones were relatively consistent from low to high.

In September of 1978 clones (approximately 100 of each accession) were grazed by wether lambs and visual palatability estimates for clones were taken approximately 27 hours after grazing began. The correlation coefficient between mean palatability estimates for each accession and mean WSC concentration for the August 1978 harvest was not significant. A more critical analysis of this association and of variability among clones will be made.

Title: Plant Germplasm--Its Introduction, Testing, Multiplication, and Preservation

Leaders: Desmond D. Dolan, William R. Sherring, and Bart J. Fiori (Northeastern Region Plant Introduction Station, Geneva, N.Y.)

Evaluations of forage crop introductions at Regional Plant Introduction Station, Geneva, N.Y., were assembled in a nine-page publication, Promising Introductions of 1978, and attached as Supplement I to the NE-9 annual report.

Evaluations of forage crop introductions by cooperators in the NE Region were assembled in a 10-page document and attached to the NE-9 annual report as Supplement II.

A report of the progress of the Research Entomologist in screening introductions for insect tolerance or resistance was attached as Supplement III to the annual report of NE-9.

Forage Legumes and Forage Grasses

A. Alfalfa

Three PI numbers in pedigree of 'Baker'--Neb.

Seven PI numbers--tolerant or resistant to common leafspot--Hunt, Neb.

PI 315481--resistant to *Stemphyllium* leafspot--Davis, Calif.

PI 253449--*Medicago pironae*--best resistance to potato leafhopper--Dr. Fiori, Geneva.

Eight PI numbers--*M. falcata*--resistant to potato leafhopper--Dr. Fiori, Geneva.

Six PI numbers--tolerant or resistant to potato leafhopper--Waterman-Loomis, Calif.

Eight PI numbers--rapid recovery after cutting.

Two PI numbers--to be further evaluated, perhaps to be used in breeding.

Two PI numbers--resistant to leafminer.

Screening Alfalfa Introductions for Tolerance or Resistance to the Potato Leafhopper

Two seasons of field testing revealed that certain alfalfa introductions (listed below) had 50 to 55% less damage than the standard cultivars. The peak leafhopper infestation was in mid-July. Later in mid-August

(beyond peak infestation), they showed 28% less damage than the standard cultivars. The numbered introductions are: M. falcata--PI 172984, 235021, 251688-89, 125830, 238750, 258754, and 263154; M. pironae: 253449.

M. pironae displayed the highest degree of resistance by showing 52% less damage than the standards at mid-August.

All resistant introductions have smaller leaves, more slender stems, prostrate habit, and slower regrowth after cutting.

Resistance appears to be associated with ovipositional non-preference.

B. Red Clover Introductions

On May 15, 1978, staff members of RPIS, Geneva, went through the over-wintering forage legumes and selected some numbers that looked promising with regard to percentage winter survival and resumption of spring growth. The notes taken on May 15, 1978, were published in DRM 206, page 7, dated June 8, 1978.

In the spring of 1978, we set out in rod rows two replicates of each of 38 introductions of red clover. Plants were set in the field in mid-May and notes were taken on July 25, August 15, September 20, and October 24. Each introduction was rated or measured for plant type, medium or mammoth, uniformity, habit, vigor, plant height, plant width, number stems, size stems, number of leaves, earliness of maturity, number heads set, susceptibility to powdery mildew, count of number of virus-infected plants, fall recovery after cutting, type of leaf markings, and number plants remaining on October 25.

Introductions in Replicate I that displayed good vigor and adaptability and should be further tested are as follows: PI 419545, 419547, 419548, 419556, 419560, 419565, 419569, 419573, and 419574.

Red clover introductions that appeared promising in Replicate II are as follows: PI 419543, 419545, 419547, 419549, 419552, and 419560.

In general, the Japanese red clovers did not make as much growth as the standard cultivars. One introduction, however, might be particularly notable; this is PI 419545, because all plants in both replicates were completely free of powdery mildew.

In Replicate I, the introductions that showed the highest percentage survival through their first growing season are as follows: PI 419542, 419545, 419547, 419549, 419550, 419555, 419560, 419561, 419565, 419569, 419573, 419574, 419575.

In Replicate II, the red clover introductions showing the greatest percentage survival at the end of their first season are the following: PI 419542, 419545, 419547, 419549, 419551, 419558, 419560, 419563, 419564, 419565, 419568.

In Replicate II, the Japanese red clovers that showed the highest percentage of survival at the end of the first growing season are as follows: PI 419542, 419545, 419547, 419549, 419551, 419558, 419560, 419563, 419565, 419568, 419569, 419573, 419574, 419575.

Some comments on the Japanese red clover introductions are as follows: PI 419545--no water markings on leaves, entirely free of powdery mildew; PI 419550--several plants without water marks on leaves; PI 419565--several plants without water marks.

C. White Clover

On May 15, 1978, at the same time notes were taken on the red clover planting, we also took notes on the best introductions in the 1977 white clover planting. Likewise, these notes were published on page 7 and 8 of DRM 206, dated June 8, 1978.

In the spring of 1978, we set in the field in rod rows, two replicates of each of 66 Japanese white clovers. Each introduction in both replicates between July and September was rated for type, uniformity, vigor, plant height, plant width, number of stolons, size of stolons, number of leaves, leafiness, size of leaves, color of leaves, leaf markings, earliness of heading, number of heads set, susceptibility to virus disease, damage due to leafhoppers, fall recovery.

In Replicate I those that were most vigorous and leafy and worthy of further trial are as follows: PI 401526, 419579, 419580, 419965, 419966, 419967, 419970, 419972, 419973, 419974, 419975, 419976, 419977, 419978, 419979, 419982, 419983, 419985, 419986, 419989, 419998, 420001, and 420007.

In Replicate II those showing unusually good vigor and leafiness are as follows: PI 401526, 419577, 419578, 419579, 419968, 419972, 419982, 419984, 419986, 420002, 420004, 420015, and G-24949.

In Replicate I, the introductions of white clover that appeared best in mid-October when the fall recovery notes were taken are as follows: PI 401526, 419972, 419973, 419978, 419985, 419998, 420001, 420002, 420003, 420007, 420016, and G-24950.

In Replicate II, the Japanese white clover introductions that presented the best appearance when the fall recovery notes were taken in mid-October are as follows: PI 401526, 419580, 419973, 419974, 419975, 419987, 419998, 420002, 420003, 420011, 420015, 420017, G-24949, and G-24961.

Some of the comments on the Japanese white clovers are as follows: PI 419579, 419965-66--most plants without leaf markings; PI. 419983--variable in leaf size; PI 420017--several types of leaf markings; PI 419993--all plants without leaf markings; PI 420002--several types of leaf markings.

No white clover introduction was completely free of leafhopper damage, but the numbers that had the least damage, rated 1 or 2, are as follows: PI 419965, 419967, 419972, 419977, 419978, 419992, 420000, 420001, 420008, and G-24944.

Forage Grass Introductions

A. Timothy

In the spring of 1978, we set in the field 346 Japanese timothies. Each replicate consisted of a rod row with 16 plants, and we had two replicates of each. Between mid-July and the end of September, notes were taken in each replicate on uniformity, habit, vigor, culm height, leaf height, plant width, number of culms, size of culms, number of leaves, distribution of leaves--basal, cauline or distributed, size of leaves, color of leaves, earliness of bloom, time of maturity, number of heads set, vigor as rated at the time of stand establishment, date of bloom, and date of harvest.

The plants were set relatively late. The month of July was very dry and hotter than usual, and by the time notes were taken in mid-August the plants had been under stress for about a month and a half. Even so, the following introductions rated good or better in vigor and leafiness and should be further evaluated: PI 419599, 419612, 419620, 419623, 419624, 419628, 419634, 419635, 419722, 419734, 419738, 419740, 419741, 419744, 419745, 419749, 419752, 419753, 419754, 419755, 419759, 419764, 419775, 419776, 419781, 419785, 419789, 419797, 419801, 419802, 419814, 419816, 419818, 419819, 419820, 219822, 419823, 419827, 419835, 419837, 419852, 419855, 419856, 419858, 419862, 419866, 419867, 419868, 419869, 419870, 419871, 419872, and G-25012.

On August 23, 1978, we staked out the 24 most attractive timothy introductions. These were the following: PI 419618, 419744, 419745, 419752, 419753, 419754, 419755, 419764, 419774, 419792, 419839, 419857, 419862, 419866, 419867, 419868, 419869, 419870, 419871, 419872, 419874, 419875, 419901, and 419923.

Comments made on these timothy introductions at that time (August 23, 1978) were as follows: PI 419618--soft, drooping leaves, late blooming; PI 419744-45--leafy; PI 419752-54--good vegetative growth, vigorous and leafy; PI 419755--soft, drooping leaves; PI 419764--vigorous, leafy, soft, drooping leaves; PI 419774--vigorous and leafy, leaves borne high on culms; PI 419792--soft, drooping leaves; 419839--soft foliage, drooping leaves; PI 419857--leaves have a bluish-green cast; PI 419862--good growth, vigorous and leafy; PI 419866-67--good vigor and growth; PI 419868--a vigorous and leafy pasture-type timothy; PI 419869-75--all vigorous and leafy; 419901--vigorous and leafy; PI 419923--erect habit.

Forage Grass Introductions--1977 Planting

B. On May 20, 1978, the following notes were taken on forage grass introductions then in their second year.

PI 251573--tall oatgrass (Arrhenatherum elatius)--excellent vigor, 100% winter survival, inclined to lodge, foliage pale green.

PI 255401 (Arrhen. elatius)--good vigor rated 8, and good color, plants 32 cm tall x 60 cm wide, partially lodged, not as pale green as some of the others.

PI 245729 (Arrhen. elatius) Turk.--excellent vigor, plants 47 cm x 70 cm, large broad leaves, not much lodging, soft, drooping foilage, some plants dark green, variable in habit.

PI 314419--Bromus inermis--excellent vigor, forage production, and growth.

G-24155 (Bromus inermis) Hung.--excellent vigor, plants 35 cm x 75 cm, partially lodged, 100% survival, soft, drooping foliage, large, broad leaves, susceptible to brown leaf spot.

Orchardgrass G-25390--drought tolerant.

Meadow fescue--3 PI numbers--outstanding, especially in regrowth.

Perennial ryegrass--1 PI number--non-pigmentation is linked to short leaf-blade.

Evaluation of Forage Legume and Grass Introductions by Cooperators

C. Under date of October 25, 1978, Dr. Bruce E. Coulman, Dept. of Plant Science, Macdonald College, McGill University, Box 4000, Ste. Anne de Bellevue, P.Q., HOA 1CO, Canada, reports on one year's evaluation of a red clover nursery. Included in the nursery were 93 red clover introductions, the cultivars Ottawa, Florex, and Hungaropoli, and five introduction lines designated PGR supplied by Mr. Roland Loiselle of Ottawa. This nursery was established in May 1978, so these notes were all taken in the first year. Each introduction was rated for vigor, growth habit, leaf markings, susceptibility to powdery mildew, degree of pubescence, earliness of maturity, and a rating for fall recovery.

Mr. Mark Testerman, Manager of Soil Conservation Service, Plant Materials Center, PO Box 295, Big Flats, N.Y., under date of October 12, 1978, reported on forage introductions as follows: Trifolium medium PI 284621 and T. medium PI 297381--both forage plants adapted to wet, marginal soils; Trifolium medium PI 371539--too much variability from plant to plant, not a good vegetative spreader.

Under date of October 16, 1978, Dr. John L. Kugler, Asst. Director of Research, Waterman-Loomis, Co., 2000 Century Plaza, Suite 110, Columbia, Md. 21094, reported on the performance of 45 alfalfa introductions under the heading leafhopper score, fall growth, and percent stand.

The numbers most tolerant to leafhopper rated 1, which indicated that the plants were green and tall on September 2, 1977, were: PI 182241, 199272, 199274, 205198, 212861, 227851, and 277883.

The most promising numbers for fall growth were rated 1, which indicated fast and rapid recovery on October 6, 1977. These numbers are: PI 182241, 199272, 199274, 205198, 212861, 227851, 277883, and 304220.

Both G-22871 and G-22877 are to be further tested for winter hardiness at Ste. Hyacinthe.

Under date of October 12, 1978, Dr. A. J. Oakes, Germplasm Resources Laboratory, USDA, BARC-West, Beltsville, Md. 20705, reported that five numbers of Eragrostis superba have potential forage value. These numbers are: PI 156049, 208095, 276055, 314045, and 364828.

Two introductions of Calamagrostis canadensis (PI 371717 and 372681) might have potential for use as ornamentals.

One introduction of Calamagrostis arundinacea (PI 325239) may have potential for use as an ornamental.

SECTION II

ENTOMOLOGY RESEARCH

Title: Selection for Potato Leafhopper Resistance in Alfalfa

Leaders: T. C. Elden and J. H. Elgin, Jr. (Beltsville Agricultural Research Center)

Laboratory and greenhouse methods for mass rearing several thousand adult leafhoppers per week and for screening large populations of alfalfa lines in the seedling stage have been developed and are now being used. Based on population counts (nymphal and adult) and damage ratings (yellowing), 47 out of 930 Medicago lines grown in the field were selected for further evaluation and are currently being grown in the greenhouse for laboratory evaluation.

Title: Alfalfa Quality Models for Use in Pest Management Studies of the Alfalfa Ecosystem

Leaders: G. W. Fick, R. G. Helgesen, and C. C. Lowe (Cornell University)

Economic evaluation of the impact of pest damage on the alfalfa crop often requires an assessment of insect effects on the nutritional value of alfalfa as livestock feed. Before insect effects can be evaluated, it must be possible to predict the dynamics of forage quality associated with environment, harvest management, and maturing of the crop. Continuing studies of environmental effects on alfalfa forage quality have now been supplemented with the development of a general forage quality model. The computer model predicts day-to-day changes in digestibility of a grass/legume forage growing under field conditions. The structure of the model is generalized so that categories of forage (e.g., live and dead, leaf and stem, grass and legume) can be treated separately. Four types of input data are required for model operation: (1) maximum observed levels of the quality measurement, (2) minimum observed levels of the quality measurement, (3) maximum possible change in the quality measurement associated with selective use by a herbivore, and (4) daily change in the quality measurement due to aging. Previous work with environmental effects on quality provide data in the fourth category for a variety of measurements including digestibility, crude protein, and acid detergent fiber. The model is designed for use as a component of a crop growth simulator, and it represents another element in the package of computerized tools being formulated to assist in pest management of the alfalfa ecosystem.

Title: Control and Bionomical Studies of Livestock and Animal Food Crop Insects in West Virginia

Leaders: Linda Butler, J. E. Weaver, and J. W. Amrine (West Virginia University)

Studies were continued on the effects of xanthane dyes on insects. Injection of erythrosin B caused an 18% reduction of hemocytes in roaches after 24 hours. Preliminary results of hemolymph protein analysis (by gel electrophoresis) indicate that some protein fractions are altered in dye-treated, light-exposed roaches.

Populations of the alfalfa-weevil parasite, Bathyplectes anurus, continue to increase at some release sites. It has become the predominant larval parasite at one location where biocontrol of the weevil has been achieved.

Study plots of no-till corn have been established to determine the long-term effects of this practice on insect populations. During 1978 plants were infested with an average of 4.7 European corn borers. Earworms, corn borers, and cutworms damaged 11% of the grain in ears.

Thirty counties were surveyed for leafhoppers of the subfamilies Cicadellinae and Gyponinae. To date, species recorded for these two subfamilies are 15 and 11, respectively.

A statewide survey of Tabanidae was continued; one new state record and 16 new county records were reported.

Title: Flea Beetle Control on Conventional and Min-till Forage Kale

Leaders: H. E. Reed and R. A. Byers (The Pennsylvania State University and U.S. Regional Pasture Research Laboratory)

Carbofuran 10G, at 1 lb ai/acre reduced feeding damage and stand losses caused by Phyllotreta cruciferae and P. striolata in both conventional and min-till kale but conventional-till suffered more damage and loss of stand. The insectivide increased dry matter yields of kale by a greater percentage over untreated kale in conventional-till than min-till plots. P. cruciferae reduced survival of seedlings, number of leaves/seedling, plant height, and dry-matter yield in greenhouse cages. A population of 1 flea beetle/plant reduced stands 43%.

Title: Evaluation of Perennial Ryegrass Cultivars for Hairy Chinch Bug Resistance

Leaders: R. H. Ratcliffe, J. J. Murray, and P. B. Baker (Beltsville Agricultural Research Center)

Plots of 15 perennial ryegrass cultivars and one 3-way blend were sampled by flotation and D-Vac methods during July and August, 1978, for hairy chinch bug infestation. Cultivars which expressed resistance in the field were evaluated in the laboratory for resistance to chinch bug nymphs in an antibiosis test. Chinch bug numbers were consistently, and usually significantly, lower on the cultivars Manhattan, Pennfine, and Score, and a 3-way blend of Manhattan, Pennfine, and Yorktown than other selections. The flotation method gave most consistent results in retrieving chinch bug nymphs and adults and was selected as the more accurate of the two methods for estimating population levels. High survival of chinch bug nymphs on Manhattan, Pennfine, and Score in a laboratory test indicated that the field response resulted from preference factors which influence adult acceptance for shelter and oviposition, rather than from antibiosis factors.

Title: Impact of Insects and Slugs Upon Establishment of Legumes in Grassland

Leaders: Robert A. Byers, W. C. Templeton, Jr., and R. L. Mangan (U.S. Regional Pasture Research Laboratory and The Pennsylvania State University)

Slugs significantly reduced stands of seedling legumes in min-till grass fields, but 2% mesurol bait effectively controlled them and reduced losses of legume plants. Carbofuran 4F and 10G both at 2.0 lbs ai/acre reduced losses in legume stands even though these materials did not control slugs. Carbofuran 10G controlled the alfalfa blotch leafminer on alfalfa in min-till fields. Red clover established most successfully, followed by alfalfa and birdsfoot trefoil. Fifty-seven phytophagous and predacious insects collected by sweep net may be important in legume establishment. Leafhoppers made up 70% of a typical sample with ca 16 leafhopper species per sample. Plots with the most forage had the most leafhoppers indicating a possible role of refuge availability in determining habitat preferences.

Title: Life Table for the Alfalfa Blotch Leafminer

Leaders: J. A. Plummer and R. A. Byers (The Pennsylvania State University and U.S. Regional Pasture Research Laboratory)

A life table constructed for 1978 showed high egg mortality (over 80%) for each of 3 generations, variable larval mortality (3.8-41.6%), and high pupal mortality (59.4-87.2%). Sex ratios (F:M) were 1.7:1, 1.1:1, and 2.2:1 respectively. The most damaging larval generation had the most eggs/sq ft (531.9).

Title: Antibiotic Resistance in *Bacillus thuringiensis* and *B. popilliae*: Plasmid DNA Transformation

Leader: Robert M. Faust (Beltsville Agricultural Research Center)

Fifteen varieties of *B. thuringiensis* and the commercial strain of *B. popilliae* were studied for their inherent antibiotic susceptibility/resistance to neomycin and kanamycin, markers to be used in plasmid and recombinant DNA transformation studies. Three varieties of *B. thuringiensis* were found to be doubly resistant, nine varieties were singly resistant (neo^r), and three other varieties were susceptible to both antibiotics (neo^s/kan^s). *B. popilliae* was susceptible to both antibiotics. One selected strain of *B. thuringiensis* was then transformed with the *Staphlococcus aureus* pUB 110 plasmid DNA carrying antibiotic resistant to neo/kan where it was expressed. Results of current research will be used in the overall goals to develop new and more potent strains of entomopathogenic bacteria by genetic manipulation for bio-control of forage pest insects.

Title: Host Preference of *Sitona hispidulus* Larvae Among Legumes

Leaders: R. A. Byers and W. A. Kendall (U.S. Regional Pasture Research Laboratory)

Legume plants were tested for 14 days on nutrient slant boards for resistance to *Sitona hispidulus* larvae. Two plants were grown per slantboard with 10 first instar larvae/plant. Head capsule width, body length, and age were used to calculate an index as follows: Head capsule width (mm) x body length (mm) divided by age in days. Red clover had larger indexes than alfalfa. Dupuits alfalfa had the smallest index (15.47) and WL318 alfalfa the largest (31.09).

SECTION III

PLANT PATHOLOGY RESEARCH

Title: Survey of Alfalfa Root Rot in Pennsylvania

Leaders: K. T. Leath, R. R. Hill, and W. A. Priddy (U.S. Regional Pasture Research Laboratory)

Alfalfa fields of various ages were sampled throughout Pennsylvania on a three-week cycle from March through October 1977 and again in the spring of 1978. One hundred roots per field were dug, washed, and rated for external and internal root rot symptoms. Fungi were isolated on selective media from roots having specific symptoms. Fungi not identifiable immediately were stored in soil; identification is now nearing completion. Development of root rot increased in severity with age of stand, was continuous and gradual, became apparent the year after seeding, and developed faster during the period from November through April than during the period from May through October. Soil samples assayed for nematodes yielded 13 species with pathogenic capabilities, but population levels were very low, probably because of early-season drought in 1977 in the areas sampled.

Title: Diseases of Warm-Season Forage Grasses

Leader: K. E. Zeiders (U.S. Regional Pasture Research Laboratory)

Diseases on warm-season grasses were surveyed at several locations in Pennsylvania. Where diseases were prevalent, the severity was rated on a 1 (no disease) to 9 (very severe) scale. In Huntingdon County, spotblotch caused by Helminthosporium was again moderate to severe on switchgrass varieties in August and October, but only slight on KY 729 as in two previous years. NY 4006 was less susceptible than four other switchgrass varieties. 'Kaw' big bluestem, which has smaller leaves, again was more susceptible to Ascochyta leafspot than NY 1145 and KY 529. On little bluestem in early August, Ascochyta leafspot was moderate on 'Camper' and NY 5188, but severe on 'Aldous' and KY 636. Indiangrass, caucasian bluestem, and old world bluestem remained essentially disease-free throughout the season. In October, spotblotch was prevalent on switchgrass in production fields in Butler, Washington, Lehigh, and Westmoreland Counties. In Westmoreland, as in Huntingdon County, there was less spotblotch on NY 4006 than on three other varieties, indicating more disease tolerance in this selection. Ascochyta leafspot was prevalent on big bluestem in Westmoreland, Washington, and Butler Counties.

Title: Decline of Alfalfa Due to *Meloidogyne hapla* in Pennsylvania

Leaders: M. G. Bookbinder, K. T. Leath, J. R. Bloom, F. L. Lukezic (The Pennsylvania State University and U.S. Regional Pasture Research Laboratory)

Portions of a Middletown, Pa., alfalfa field were found to be infested with northern root-knot nematode, *Meloidogyne Hapla*. Nematode infection reduced the dry weights of Saranac AR plant tops by 63.2% compared with non-infected plants from the same field; root dry weights were reduced by 60.8%. The heaviest infestation, thus the severest stunting of plants, was found in portions of the field which had been planted in alfalfa continuously for four years prior to the 1978 growing season. Areas of the same field which had been under corn for three years prior to seeding with alfalfa in April, 1978, showed little or no infestation. The mean number of *M. hapla* root galls observed on each plant was positively correlated with the mean dry or fresh top weight of infected plant tops ($r^2 = 0.861$).

Title: Effect of Magnesium on Stemphylium Leaf Spot of Alfalfa

Leaders: K. T. Leath and C. F. Gross (U.S. Regional Pasture Research Laboratory)

The severity of Stemphylium leafspot was compared in the greenhouse on alfalfa ranging in Mg concentration from 0.12 to 2.00%. Disease severity was significantly and negatively correlated with Mg content. Defoliation caused by disease was also greater in plants with lower levels of Mg. Mg levels exceeding 0.5% reduced disease severity, but at Mg levels of 0.12 to 0.40%, which are comparable to those of field-grown alfalfa, plants were susceptible to Stemphylium leafspot. It is not likely that the severity of this disease in the field will be modified greatly by Mg fertilization practices.

Title: A *Septoria* Disease of Reed Canarygrass

Leader: K. E. Zeiders (U.S. Regional Pasture Research Laboratory)

A leaf disease caused by a species of *Septoria* was found on spray-irrigated reed canarygrass (*Phalaris arundinacea* L.) at the Pennsylvania State University Wastewater Renovation and Conservation Project, approximately four km north of State College, Pa. Mature lesions are elongated, buff-colored spots or blotches. The fungus caused serious disease only on reed canarygrass in greenhouse inoculation tests.

Twelve forage grasses, five cereal grains, and one forage legume were non-susceptible, while four grasses were highly resistant to Septoria. Twenty-five reed canarygrass genotypes of diverse origin varied from resistant to highly susceptible to Septoria. Differences among disease severity mean ratings were significant at $P < 0.01$. Thus, the prospects for developing lines with resistance to this pathogen are good. Septoria spp. that attack reed canarygrass have not previously been reported in eastern United States. The pathogenicity of a Septoria spp. on reed canarygrass was demonstrated for the first time. The fungus was similar in some respects to S. bromi var. phalaricola.

Title: Studies on the Biochemistry of Plant Pathogenesis

Leaders: D. L. Gustine and B. G. Moyer (U.S. Regional Pasture Research Laboratory)

A study was initiated to determine whether production of the phytoalexin, medicarpin, is correlated with disease resistance in alfalfa. Isogenic lines of alfalfa callus-tissue cultures were initiated from sterile, germinated seeds of Dupuits (disease resistant) and Ranger (disease susceptible) cultivars. For each cultivar, 25 plant/callus pairs were established; that is, from each germinated seed, plants and callus tissue were cloned. Callus from each of the lines was treated with mercuric chloride or Pithomyces chartarum and quantitatively assayed for medicarpin levels after 48 hours. The amounts found ranged from 0 to 155 µg/g for Dupuits and 0 to 73 µg/g for Ranger. The cloned plants will be scored for foliar disease resistance and assayed for medicarpin production in leaves.

Title: Plant Resistance and Pathogen Ecology in Relation to Infection of Forage Crops

Leader: R. L. Millar (Cornell University)

Two isolates of the low temperature basidiomycete that causes snow mold of alfalfa produced enzymes that hydrolyzed amydalin to produce hydrogen cyanide but these were either weakly active or inactive on crude cyanogenic substrates from birdsfoot trefoil and white clover or on pure linamarin. These results suggest that for the W_2 isolate, which is cyanogenic, that linamarin may not serve as the source of cyanide as has been reported. Formamide hydrolyase, which has been associated with cyanide detoxification for many fungal pathogens, was not detected in initial tests with the low temperature basidiomycete.

The extent of passive movement of zoospores by flowing soil solutions was determined for four soils differing in texture: a sand, a sandy loam, a loam, and a silt. In sand, motile zoospores were transported up to 30 cm in less than 2 hr when water had flowed 65.0 cm along a soil column. Zoospore movement was progressively reduced in sandy loam and loam soils and did not occur in the silt soil owing to small pore radii. Passive movement of encysted zoospores required soil pores of larger diameter than was required for motile zoospores.

Title: A Variable-spored Isolate of *Bipolaris* Pathogenic on Orchardgrass and Corn

Leader: K. E. Zeiders (U.S. Regional Pasture Research Laboratory)

A species of *Bipolaris* (*Helminthosporium*) causing severe leafspot and blotch was isolated from orchardgrass (*Dactylis glomerata* L.) in Centre County, Pa. The fungus regularly produced a certain proportion of curved, branched, or saturate conidia in culture and on leaves of inoculated orchardgrass plants. In perfect state studies, dark sclerotial bodies, or protothecia, of the *Bipolaris* developed on three culture media, on sterilized corn leaf tissue on Sach's agar, and on inoculated orchardgrass leaves, but an acigerous or perfect state did not develop in any case. In greenhouse inoculations, the pathogenicity of the *Bipolaris* was tested on 18 gramineous species representing 11 tribes. Only orchardgrass and corn (*Zea mays* L.), representing the tribes *Festuceae* and *Tripsaceae* respectively were susceptible. Twelve forage grasses and four small grains, representing nine tribes, were nonsusceptible, thus indicating a very narrow host range among *Gramineae* for this pathogen. Results indicate that this unusual *Bipolaris* is a potential threat to orchardgrass and corn, especially during the warm summer months. The ability of this fungus to attack corn was demonstrated for the first time.

SECTION IV

GROWTH, PHYSIOLOGY, AND CLIMATIC EFFECTS

Title: Feasibility of Perennial Ryegrass and Hybrid Derivatives as Northern Forage Crops

Leaders: G. M. Wood, R. P. Cohen, and J. G. Welch (University of Vermont)

The first year (1978) dry matter yields of perennial ryegrasses harvested under a 4-cut system indicated susceptibility to crown rust (Puccinia coronata) to be the most important factor in limiting yields. It was found to be severe in cultivars Derby, Servo, Yorktown, and Citation; moderate in Svea, Eton, Diplomat, and K8-142; light in Birdie; and very light in Reveille, Tetrelite, and K2-182. Winter injury during the 1977-78 season seemed to be a factor only where standing water caused kill in low spots. Adequate snow cover protected other areas.

A more precise laboratory technique (see 1977 report, page 6), involving alcohol-bath freezing in glass tubes, was developed to measure relative cold hardiness of perennial ryegrasses. Relative survival of 8-week old seedling sods after artificial freezing is shown in the following table:

Average Survival of 8-Week Old Seedling Perennial Ryegrass Sods Following Gradual Freezing

Cultivar	Percent Survival	Cultivar	Percent Survival
Manhattan	57.9	R-33	35.0
Omega	54.3	Ranger	34.3
Yorktown II	50.0	Servo	32.9
Yorktown I	47.9	Norlea	30.7
Birdie	46.4	Svea	30.7
H 969	44.3	Ensporta	29.3
Pennfine	42.1	Lp 272	28.6
Diplomat	41.4	Lp 203	27.9
R-35	38.6	Elka	27.9
R-34	37.9	NK-100	25.0
R-32	37.9	M 456	24.3
Regal	37.9	Venlona	21.4
Derby	37.1	Caravelle	15.7
Loretta	37.1	Linn	8.6
Citation	35.7	Reveille	7.1
MP-1	35.7	Tetrelite	5.7

Title: Influence of Climatic Factors and Fertilization with N, K, and Mg on Uptake of Ions by Grass and Small-Grain Forages

Leaders: R. Ellis, Jr., and D. L. Grunes (Kansas State University and U.S. Plant, Soil, and Nutrition Laboratory)

Objectives of this research are to (1) determine the influence of climatic factors such as soil moisture level and fertilization with N, K, or Mg on relative uptake of ions by grass and small-grain forages and (2) study the influence of soil moisture on the differential ion activities of K, Ca, and Mg in the soil with regard to uptake by grass and small grain forages.

Several reports indicate that outbreaks of grass tetany are most severe when cattle are grazing cool-season forages growing on soils that are high in moisture. Therefore, two experiments were conducted to obtain a better understanding of the interaction between soil moisture, cation availability, and cation uptake by wheat. In one study, equilibrium soil solution was extracted from three soil types and analyzed for K, Ca, and Mg concentrations. In another study wheat was grown on the soils under "wet" and "dry" moisture regimes to determine whether changes found in the cation concentrations in the equilibrium soil solution would be reflected in the cation composition of the small grain. The potential for outbreaks of grass tetany in cattle consuming the forage was estimated from the equivalent ratio K/(Ca+Mg).

Analysis of the equilibrium soil solution showed that the activity ratios in the solution phase tended to remain constant, as predicted by the principles of thermodynamics governing the monovalent-divalent cation equilibria under various moisture regimes. The molar concentrations of K, Ca, and Mg increased nonproportionally as the soils began to dry, resulting in higher K/(Ca+Mg) molar ratios under "wet" conditions than under the "dry" conditions. These changes reflected the increased bonding of divalent cations by colloidal particles as the soils approached water saturation. Such changes in the cation composition of the soil solutions were subsequently reflected in wheat forage.

Equivalent ratios of K/(Ca+Mg) were higher in wheat grown under "wet" conditions than in that grown under "dry" conditions. The increases in the equivalent ratios in the forage were due primarily to significant decreases in the Ca and Mg concentration in the wheat forage, definitely reflecting the lower concentrations in the soil solution under wet soil conditions.

The results of these experiments demonstrated the thermodynamically predicted changes in soil-solution-cation concentrations. They also showed that increased soil moisture, in addition to affecting aeration and soil temperature, caused chemical changes in the soil solution composition that influenced composition of wheat forage and increased its potential for inducing grass tetany in grazing cattle.

Title: Lime Responses of Kentucky Bluegrass, Tall Fescue, and Fineleaf Fescue Cultivars on an Acid, Aluminum-toxic Soil

Leaders: J. J. Murray, L. C. Taylor, and G. Jones (Beltsville Agricultural Research Center and Virginia Polytechnic Institute and State University)

To evaluate laboratory screening methods for acid-soil tolerance, field plots of sensitive and tolerant cultivars (based on laboratory tests) to acid-soil conditions were established on Tatum soil limed to four pH levels. A significant interaction was obtained between pH levels and cultivars for yield and disease injury. Performance of bluegrass was related more to relative disease resistance of the cultivars than to pH tolerance in the laboratory. Laboratory and field tests with fescues were significantly positively correlated with respect to clipping yields and turfgrass quality among soil pH levels. In general, disease damage was more severe at the lower pH levels.

Title: Intercropping Beans and Corn

Leaders: M. B. Materu and W. B. Bryan (West Virginia University)

The effects on total dry-matter and grain yields of corn and beans intercropped in the same row were investigated. Two corn populations (40,000 and 50,000 plants/ha) and three pole bean populations (20,000, 40,000, and 80,000 plants/ha) were used with 0, 84, and 168 kg of N/ha in a factorial experiment. Two harvests were made, one at physiological maturity of the corn, when the entire above-ground plants was taken, and the second, after frost when only grain was harvested. Corn and beans yielded significantly more at the higher populations. Corn intercropped with beans yielded less grain but total DM production (corn & beans) was not different comparing corn alone and corn with the lowest bean population. Nitrogen up to 84 kg/ha increased yields of corn and up to 168 increased yields of beans.

Title: Prediction of Alfalfa Production for Forage Systems Analysis

Leaders: G. W. Fick, R. A. Milligan, and C. J. Sniffen (Cornell University)

One of the major factors limiting alfalfa production in New York State is poor soil drainage. Water table levels periodically rise to heights sufficient to inhibit alfalfa growth on an estimated two-thirds of the State's alfalfa acreage. Earlier computer models of alfalfa growth could not simulate the crop's response to this stress. A model was

designed to provide this capability in an updated version of ALSIM, the ALfalfa SImulation Model developed at Cornell. The new model, written in CSMP, consists of two distinct sections. The first simulates fluctuations of water table levels in New York State soils. Forcing functions controlling the rate of water table recharge are weekly precipitation, pan evaporation, and mean air temperature. The rate of deep percolation is determined by the soil drainage class of the soil being simulated. The second section simulates the crop response when the water table rises to injurious levels. This response is determined by mean weekly soil temperature and the stage of maturity of the crop as well as height of the water table. Data to support this section of the model were collected in greenhouse and growth chamber studies with alfalfa plants grown under flooded soil conditions at various temperatures and periods of time. The total model is yet to be validated.

Work was also initiated to develop a weather simulation model for use with ALSIM. The weather model of the potato-blight and apple-scab programs will be extended to a full year, rather than the growing season. Since alfalfa is a perennial crop, its production is influenced by winter as well as summer weather, and extension of the model will enable the effects of winter weather to be included in the simulation. Additional objectives of the weather modeling project include development of options for using combinations of real and simulated weather in the alfalfa model where field weather records are incomplete. Methods for simulating weather cycles will also be developed. The completed weather model will allow simulation of the interaction of weather and alfalfa management and possibly aid in the identification of climatic change and its consequences in crop production.

Title: Improving Biological Nitrogen Fixation in Forage Legumes and Grasses

Leaders: L. D. Owens and C. Sloger (Beltsville Agricultural Research Center)

Azospirillum sublines carrying resistance markers for rifampicin and streptomycin were derived. These markers were demonstrated to provide unambiguous identification of these strains in soil. In soil pot experiments, inoculation of corn seed with numbers of azospirilla ranging from 10 to 1 million per seed resulted in the same number of bacteria (about one million) per gram of dry root 14 days later. In a field experiment, the number of marked Azospirillum increased to 1 million per gram dry weight of root at 14 days after planting, then declined to 1 thousand per gram after one month, and remained at that level for the rest of the season. Native non-marked Azospirillum-like bacteria greatly outnumbered the marked inoculated strain during the period from one month after planting to the end of the season.

Preliminary evidence was obtained that root-microbial associations of certain marsh grasses fix nitrogen from the atmosphere.

Estimates of the quantity of nitrogen derived from associative nitrogen fixation were made on corn grown in plots which received either 2 or 6 kg ^{14}N enriched dry matter m^{-2} before planting. This technique labels the organic nitrogen fraction of the soil and provides different amounts of mineralized nitrogen to the plants during the growing season. Azospirillum was used as inoculum at planting. Dry matter production from inoculated and uninoculated plots were similar. Plant material will be analyzed to determine quantity of nitrogen fixed.

Title: Forage-Livestock Systems for Land with Soil and Site Limitations

Leaders: W. C. Stringer, T. W. Bowersox, W. L. Kjelgaard, R. H. Fox, E. J. Partenheimer, and L. L. Wilson (The Pennsylvania State University)

In an experiment to test for P efficiency in forages under field conditions, Caucasian bluestem produced the highest dry matter yield of the 18 warm-season grasses and four cool-season forages grown on a low-available-P soil (7 ppm Bray No. 1) for the second year in a row.

Adaptation studies with cool-season forage species were initiated on a shallow stony site of pH 5.8 and low to medium P, K, Ca, and Mg. Preliminary data indicate successful establishment of most species.

Results from a wood-lot wintering trial for beef cows indicated potential damage to young tree seedlings at stocking rates of 15 cows/ha but not at 5 cows/ha. Cows wintered in wood lots showed greater wintering gains than cows in an open, unsheltered lot.

A study of natural vegetation on three types of uplands in Pennsylvania for forage-beef potential was instituted. The upland types include 1) Allegheny Plateau, 2) Ridge and Valley-acid shale, and 3) Ridge and Valley-sandstone-shale soils. Abandoned open lands provide most herbaceous dry matter followed by young pine stands and maturing hardwoods. Plant quality and toxicity, soil nutrient status, and wildlife impact estimates are being made.

Title: Ecology of Grasses and Legumes

Leader: Milton A. Sprague (Rutgers University)

Microclimate studies were discontinued at the end of the growing season 1978. Summarizing the findings of the past years, microclimate-slope-crop performance studies identified major differences in performance of Medicago, Dactylis, Lolium, Triticum, Secale, and Zea species on E-, S-, W-, and N-facing slopes of an 8' pyramid sloping 27°10' from the horizontal. Rainfall was greatest on the N and W slopes in summer and N and E in spring and fall; soil moisture remained highest on the N and lowest on S slopes. Average protein contents of alfalfa and orchardgrass were higher on N slopes. Floral maturity of all species was induced earlier on S slopes. Dew disappearance was within a very few hours of sunrise on the E slope, sequentially delayed on the S, W, and finally the N slope until early afternoon. Leaf diseases were associated with dew and relative humidity. Most plant responses were most closely related to the incoming energy budget as measured by net radiation and soil and air temperatures and the effect on relative humidity near the soil, evaporation, and soil moisture availability. Analyses of crowns and roots during late winter and spring showed carbohydrate losses related to exposure and temperatures which separated N-S slopes by up to 2 weeks. Differences in net radiation between N and S slopes were greatest on clear days in winter by a factor of up to 5 times and least in summer. No differences existed during rain.

Title: Physiological Processes Associated with Regrowth of Alfalfa

Leaders: D. W. Koch and T. R. Peoples (University of New Hampshire)

A severe (0.0 mM substrate K) and mild (0.6 mM substrate K) potassium deficiency, compared to an adequate level of tissue potassium (4.8 mM substrate K) in alfalfa grown hydroponically, produced a significant decrease in photosynthesis and photorespiration, but an increase in dark respiration. Both deficient potassium levels increased mesophyll resistance to CO_2, but only the severe deficiency increased stomatal resistance. Photosystem I and II activity of isolated chloroplasts was not affected by potassium deficiency. The apparent activity of a crude RuBPc preparation was significantly reduced in severely deficient plants. Activity of the enzyme could not be restored to normal rates by the addition of potassium to the reaction medium. The specific activity of RuBPc isolated from severely potassium deficient and potassium sufficient leaflets was not significantly different, suggesting that potassium does not function in RuBPc activity. Incorporation of ^{14}C-leucine into RuBPc by potassium-deficient leaflets was reduced to 15% of potassium-sufficient leaflets.

Title: Effects of Genotypes and Environments on Growth and Feeding Quality of Forages

Leaders: W. A. Kendall and W. C. Templeton, Jr. (U.S. Regional Pasture Research Laboratory)

The objective of these experiments was to evaluate the slant-board culture technique (Crop Sci. 14:317, 1974) as a means for classifying plant genotypes and cultivars for root characteristics. Plants of 'Saranac,' 'Moapa,' and 'Victoria' alfalfa and 'Kenland,' 'Kenstar,' and 'Pennscott' red clover were grown on slant-boards and harvested at 3-week intervals for 21 weeks. Differences were obtained in the size and branching habits of roots for individual plants and cultivars. These root characteristics may relate to persistence of the plants in forage stands.

Title: Preliminary Observations from a Study of the Vegetation on Open and Forested Uplands in Pennsylvania

Leaders: D. A. Devlin, T. W. Bowersox, W. C. Stringer, L. L. Wilson, and M. A. Lucas (The Pennsylvania State University)

The beef production potential of three native, upland communities in Pennsylvania is currently being investigated. The communities are: (1) open, abandoned farm or pasture land; (2) maturing hardwood stands less than 40% stocked with trees; and (3) young conifer stands not fully occupying the site. Three locations within the state are under study: (1) Allegheny Plateau; (2) Ridge and Valley--acid shale soils; and (3) Ridge and Valley--mixed sandstone-shale soils. Herbaceous dry matter production for the three communities within each location were analyzed. Comparisons were made for all seasonal-community-location interactions. Significant differences ($P<0.05$) in herbaceous dry matter production were noted among seasons (spring, summer, fall), upland communities, and locations within the state. Seasonal differences were significant only among old field communities. Differences in communities were significant for nearly all season-location combinations. Locations were significantly different for all summer-community combinations.

SECTION V

WEED INVESTIGATIONS

Title: Resistance of T-68 Birdsfoot Trefoil to 2,4-D

Leaders: H. M. Schaaf and D. L. Linscott (U.S. Plant, Soil, and Nutrition Laboratory)

The varieties T-68, Viking, and Empire birdsfoot trefoil were tested in the field for tolerance to 2,4-D. T-68 had been selected previously for resistance to this herbicide. Applications of 0, 1/4, 1/2, 1, and 2 kg/ha 2,4-D were made to birdsfoot trefoil at the 20 cm stage. Numbers of surviving plants were determined before and after a winter. Seed and forage yields were taken the year following treatment. T-68 retained seed and forage yields far better than Viking or Empire after the 2,4-D treatment. However, the most striking advantage of T-68 plants treated with 2,4-D was superior winter survival. Survival of T-68 in 1978 was not affected by the 1/4-, 1/2-, or 1-kg/ha rate and at the 2-kg/ha rate stands averaged only 20% lower than the control. Viking stands suffered progressively greater loss with each increment of herbicide and at the 2-lb rate averaged 84% lower than the control. This study confirms in the field the resistance of T-68 Birdsfoot trefoil to 2,4-D. For weed control in T-68 seed production, a 1 kg/ha treatment on T-68 is practical.

Title: Weed Control in Birdsfoot Trefoil Seed Fields

Leaders: D. L. Linscott and R. H. Vaughan (U.S. Plant, Soil, and Nutrition Laboratory)

Sixteen herbicide combinations were evaluated for perennial broadleaf weed control in Birdsfoot trefoil seed fields. The following treatments resulted in seed yields in excess of 75 kg/ha over controls: (a) 2,4,5-TP - fall, 1/2 kg/ha; (c) simazine + dalapon spring, 2 + 3 kg/ha; 2,4,-DB ester + dalapon - spring, 0.375 + 3.0 kg/ha.

Title: Biological Control of Thistles Attempted

Leader: S. W. T. Batra (Beltsville Agricultural Research Center)

The European weevil, Rhinocyllus conicus, has been established in Frederick Co., Maryland, for control of Carduus thistles.

Title: Weed Control in No-tillage Forage Establishment Systems

Leaders: D. L. Linscott and E. B. Rayburn (U.S. Plant, Soil, and Nutrition Laboratory)

Research on establishment of forages has expanded considerably in the last few years in both State and Federal projects. The increased interest stems from the development of more effective herbicides and planting equipment which in combination can result in high probabilities of successful establishment. The likelihood of higher energy costs in the future gives the research added significance. Should no-tillage forage establishment probabilities be sufficiently high, farmers likely will adopt the practice extensively in the future. This report discusses preliminary results of a pilot-test program conducted on a variety of sites representative of Northeastern agriculture.

Powr-till planting of legumes in corn stalks or corn stubble. In a total of 6 different experiments over a two year period involving replicated trials comparing the direct planting (powr-till) of alfalfa, birdsfoot trefoil, and red clover in corn stalk land versus disking plus powr-till drilling versus the conventional plow-fit-plant procedures, we found no significant differences in legume establishment using yield as the primary measure. Similarly, in corn stubble, a less difficult no-tillage establishment situation, legume stands and yields were comparable among powr-till planting, disk and powr-till planting, and conventional till-planting systems.

No-tillage planting in small grain stubble. On May 15, June 12, and August 17, 1978, alfalfa was planted into oat stubble directly with (1) a John Deere powr-till drill, (2) a Tye drill, (3) a Zip seeder and after (4) disking or (5) plowing, with a Brillion seeder. On basis of stand and yield, the powr-till plantings were superior to the Tye, Zip, or disking and Brillion plantings which in turn were superior to the plowed and Brillion plantings. On basis of stand, the no-till plantings in the fall of '78 were clearly superior with the powr-till leading the group. In 1978 at this experimental location, the moisture relationships definitely favored no-tillage plantings. Similar successes were noted in planting legumes in wheat and rye stubble. Some trouble from volunteer grain was experienced in the fall plantings.

Powr-till planting of birdsfoot trefoil in six different grass sods after herbicide treatment. This year, 1978, was the third year of a study on the relative effectiveness of glyphosate, paraquat, and dalapon for controlling timothy, perennial ryegrass, bluegrass, tall fescue, orchardgrass, and bromegrass prior to powr-till planting of birdsfoot trefoil. The soil was poorly drained and shallow (12-15 inches to fragipan), typical of large areas of the Northeast. Over the three year period, glyphosate was generally superior to paraquat or dalapon in killing or suppressing grass and weeds. However, there were significant differences in species susceptibility. Glyphosate was generally superior to paraquat and dalapon in controlling orchardgrass, ryegrass, and

timothy, and was effective on the rest. Paraquat was superior to the other two herbicides in controlling tall fescue and bluegrass. It was fairly effective on timothy but orchardgrass and bromegrass generally outgrew the effect to the detriment of the trefoil seedlings. Dalapon compared favorably with glyphosate in bromegrass control but was generally less satisfactory on other species.

No-till planting of alfalfa, birdsfoot trefoil, and red clover in mixed grass-weed sods. In 1978, all but 2 of 38 plantings (95%) of red clover or birdsfoot trefoil directly into killed sods whether in spring or fall were successful where glyphosate was the herbicide used for sod control. Where paraquat was the herbicide, 21 of 27 plantings were satisfactory (78%). (In these cases, paraquat was used at higher than labeled rate, 1 lb/A.) With alfalfa planted in sod (not in grain stubble as in paragraph 2 or 3), 8 of 12 or 67% of the trials were successful. Failures of alfalfa to establish were attributed to insect damage and annual grass competition. In case of birdsfoot trefoil and red clover, failures were caused by inadequate grass or broadleaf weed control.

Vegetative control with cattle and herbicides prior to reseeding pastures. Generally, severe grazing pressure plus a glyphosate application prior to powr-till planting of birdsfoot trefoil or red clover resulted in superior establishment compared with either treatment alone. Grazing plus paraquat before planting resulted in a satisfactory sward at one site but not at another. In the latter case, grass competition became too severe.

Banded vs broadcast applications of paraquat or glyphosate during powr-till planting. Generally the broadcast herbicide applications resulted in superior stands and will probably be the method of choice in no-tillage establishments for hay. Establishments for pasturage is another matter, particularly if one is considering red clover as the legume component. In this case the banding method is practical.

In general, 1978 was the most satisfactory year for no-tillage forage establishment in our experience. On sites properly limed and fertilized, where weeds, grass, and insects were controlled, and where the killed plant residue was not too great in amount, the forage establishments were successful. Insect and weed control in sod-planted alfalfa remain as significant problems.

Title: Economic Losses Due to Weeds--Forage Legumes

Leaders: D. L. Linscott (Survey Coordinator, USDA-SEA-AR), R. A. Peters (Connecticut), W. H. Mitchell (Delaware), V. H. Holyoke (Maine), J. V. Parochetti (Maryland), J. Vengris (Massachusetts), J. B. Mitchell (New Hampshire), R. D. Ilnicki, J. R. Justin, J. A. Meade (New Jersey), J. F. Hunt, D. L. Linscott, R. R. Seaney (New York), J. E. Baylor, N. L. Hartwig (Pennsylvania), R. C. Wakefield (Rhode Island), T. R. Flanagan (Vermont), and O. E. Shubert, C. B. Sperow, Jr. (West Virginia)

In response to a request by the Weed Science Society of America's (WSSA) Committee on Weed Losses, experts from each of the 12 Northeastern States were contacted for their best estimates of losses in forage legumes directly or indirectly caused by weeds. A weed population appraisal also was requested. The formats used were those suggested by the WSSA, modified to some extent by the Crop Survey Coordinator. Results of the inquiry are given in Tables 1, 2, and 3.

The data indicate that weeds in forage legumes alone cost the farmer over $160 million dollars a year for the 12 Northeastern States (Tables 1, 2). In alfalfa, over 88 million dollars are lost due to weeds. Over 75 million dollars are lost due to weed infestations in red clover, birdsfoot trefoil, and other legumes. These loss estimates consider the present state of the art for controlling weeds in the forage legume crops. By category, dollar losses are incurred as follows: forage quality--$88.7m (54%), forage yield--$33.5m (22%), increased land preparation--$14.4m (9%), cost of harvesting--$16.9m (10%), cost for herbicides--$4.5m (3%), damage from herbicides--$3.8m (2%). More detailed data by forage crop and by State are included in Tables 1 and 2.

In the population survey, problem weeds most frequently mentioned in a listing of the top ten were: dandelion, quackgrass, yellow rocket, chickweed, annual grasses (foxtail, fall panicum, annual bromes, barnyard grass), curley dock, white cockle, lambs quarters, wild mustard, and pigweed (Table 3). Weeds reported as appearing with increasing frequency include yellow nutsedge, fall panicum, crabgrass, milkweed, and fleabane.

CATEGORY I - ECONOMIC LOSSES DUE TO WEEDS - FORAGE LEGUMES

Table 1. Estimated Losses Due to Weeds in Alfalfa. (Total Values Expressed in Thousands of Dollars, Acres in Thousands of Acres).

			PENN	NY	W VA	VT	MD	NJ	MASS	NH	CONN	ME	DEL	RI	TOTAL
Total Acres			825	990	90	81	68	55	36	22	16	10	8	3	2204
Cost of Herbicides	a.	Acres involved	206.25	144.5	9	3.5	6.8	55	4	5	9.6	1	0.6	0.2	445.5
	b.	Cost ($) per acre	5.25	11.1	8	12.0	4.5	12.5	12.0	12.0	2.6	6.75	6.75	6	8.22
	c.	Total Loss Value	1083	1604	72	42	30.6	687.5	48	60.0	25.0	6.75	4.1	1.2	3664
Loss in Yield	a.	Acres Involved	300	310	16	70	17	27.5	36	22	16	4	5.5	2	826
	b.	Pounds/A	500	500	500	1400	860	1200	500	1050	800	1000	500	500	--
	c.	Cost ($) per acre	20	20	15	21	34.4	48	20	42	32	25	20	20	22.06
	e.	Total Loss Value	6000	6200	240	1470	585	1320	720	924	512	100	110	40	18221
Loss in Quality	a.	Acres Involved	618.75	600	16	40	6.8	27.5	36	3.3	4	4	5.5	2	1364
	b.	Cost ($) per acre	40	30	6	17	35.0	24.0	16	28.0	32	10	20	20	33.29
	c.	Total Loss Value	2475	18000	96	680	238	660	576	92.4	128	40	110	40	45410
Loss in Extra Land Preparation and Cultivation	a.	Acres Involved	31.5	20	4	NA	Neg	Neg	Neg	5	0.5	Neg	0.3	0.1	61.4
	b.	Cost ($) per acre	150	85	15					10	100		100	100	107.9
	c.	Total Loss Value	4725	1700	60					50	50		30	10	6625
Loss in Increased Cost of Harvesting	a.	Acres Involved	206.25	200	20	40	13.6	Neg	Neg	Neg	Neg	Neg	Neg	Neg	480
	b.	Cost of ($) per acre	40	15	2	5	10								24.22
	c.	Total Value	8250	3000	40	200	136								11626
Crop Injury from Herbicides	a.	Acres Involved	10.3	144.5	0.8	0.1	Neg	Neg	Neg	Neg	9.6	Neg	Neg	Neg	165.3
	b.	lb/A	200	400	500	100					80				--
	c.	Cost ($) per acre	8	18	15	2.0					3.2				16.49
	d.	Total Loss Value	82.5	2601	12	0.2					30.7				2726
Total Value			44890	33105	520	2392	990	2668	1344	1126	746	147	254	91	88273

* Data includes legumes alone and legume-grass mixtures.

CATEGORY I - ECONOMIC LOSSES DUE TO WEEDS - FORAGE LEGUMES

Table 2. Estimated Losses Due to Weeds in Birdsfoot trefoil, Red Clover and other legumes (Total Values Expressed in Thousands of Dollars, Acres in Thousands of Acres.

			Birdsfoot Trefoil				Red Clover					Other Legumes			
			PA	NY	VT	CONN	PA	NY	VT	CONN	ME	PA	NY	ME	TOTAL
Total Acres			100	495	1.6	1.0	1,100	250	204	4	20	55	350	10	2,591
Cost of Herbicides	a.	Acres Involved	5	42.75	0.5*	0.75	Neg.	18	20	0.4	10	2.5	Neg	Neg.	99.9
	b.	Cost ($) per acre	5.25	11.1	24	1.3		8	4	6.0	3.5	8.0			7.97
	c.	Total Loss Value	26	475	12	0.975		144	80	2.4	35	20			796
Loss in Yield	a.	Acres Involved	50	248	1	0.25	500	200	120	4	5	2.5	125	1.5	1,257
	b.	Pounds/A	500	500	75*	1,200	300	300	400	600	600	200	200	400	--
	c.	Cost ($) per acre	20	20	150	36	12	12	10	15	18	8	8	8	13.45
	d.	Total Loss Value	1,000	4,960	150	9	6,000	2,400	1,200	60	90	20	1,000	12	16,902
Loss in Quality	a.	Acres Involved	95	400	1	0.25	1,100	125	Not	1	5	2.5	125	1.5	1,856
	b.	Cost ($) per acre	30	30	25	18	20	20	Est.	30	5	20.0	130	5	23.31
	c.	Total Loss Value	2,850	12,000	25	4.5	22,000	2,500		30	25	50	3,750	7.5	43,242
Loss in Extra Land Preparation and Cultivation	a.	Acres Involved	14.25	17.5	Neg.	Neg.	27.5	7	Not			0.25	7.5		74
	b.	Cost ($) per acre	130	85			115	85	Est.			175	85		105.13
	c.	Total Loss Value	1,853	1,488			3,162	595				43.75	637.5		7,779
Loss in Increased Cost of Harvesting	a.	Acres Involved	25	150	1	Neg	Neg	75	Not			None	75		326
	b.	Cost ($) per acre	30.0	15	25			15.	Est.				15		16.18
	c.	Total Value	750	2,250	25			1,125					1,125		5,275
Crop Injury from Herbicides	a.	Acres Involved	Neg	42.75	0.1	0.75	None	18	Tr.	4		0.05	Neg		65.7
	b.	lb./A		500	25*	60		300		60		1,500			--
	c.	Cost ($) per acre		20	6.5	1.8		12		1.5		45			16.37
				855	0.6	1.35		216		0.6		2.25			1,076
Total Value			6,479	22,028	213 (*seed)	16	31,162	6,980	1,280	93	150	136	6,513	20	75,070

Data includes legumes alone and legume grass mixtures.

Table 3. Weed Population Appraisal - Category Forage Legumes

Most Common Weeds.

	CONN	DEL	ME	MD	MASS	NH	NJ	NY	PENN	RI	VT	W VA
1.	Quackgrass	Annual Grasses	Lambs Quarters	Chickweed	Crabgrass	Quackgrass	Fall Panicum	Quackgrass	Quackgrass	Annual Grasses	Quackgrass	Chickweed
2.	Dandelion	Crabgrass	Mustard	Dandelion	Fox Tails	Nutsedge	Nutsedge	Yellow Rocket	Yellow Rocket	Crabgrass	Chicory	Yellow Rocket
3.	Bluegrass	Barnyard Grass	Redroot Pigweed	Lambs Quarters	Lambs Quarters	Chickweed	Crabgrass	White Cockle	White Cockle	Barnyard Grass	Fleabane	Quackgrass
4.	Chickweed	Fox Tails	Quackgrass	Pigweed	Pigweed	Yellow Rocket	Yellow Rocket	Dandelion	Dandelion	Fox Tails	Chickweed	Fox Tails
5.	Shepards Purse	Quackgrass	Barnyard Grass	Wild Turnip	Plantains	White Cockle	Dandelion	Chickweed	Shepards Purse	Quackgrass	Cinquefoil	Fall Panicum
6.	Yellow Rocket	Ragweed	Fox Tails	Shipards Purse	Dandelion	Curley Dock	Curley Dock	Annual Grasses	Field Pepper Weed	Ragweed	Dandelion	Crabgrass
7.	Curley Dock	Pigweed	Dandelions	Downy Brome	Barnyard Grass	Wild Mustard		Wild Mustard	Chickweed	Pigweed	Annual Grasses	Curley Dock
8.	Horse Nettle	Chickweed	Crabgrass	Fox Tails	White Cockle	Wild Radish		Curley Dock	Plantains	Chickweed		Dandelion
9.	White Cockle	Dandelion		Fall Panicum	Hoary Alyssum	Lambs Quarters		Lambs Quarters	Annual Grasses	Dandelion		Bittercress
10.	Bed Straw	Curley Dock		Yellow Rocket	Curley Dock	Ragweed		Field Pepper Weed	Lambs Quarters	Curley Dock		Yellow Nutsedge

New Weeds Appearing or Those Increasing as a Problem in Forage Legumes

	CONN	DEL	ME	MD	MASS	NH	NJ	NY	PENN	RI	VT	W VA
1.	Crabgrass	Crabgrass	Milkweed	Summer Annuals	Fall Panicum	Crabgrass	White Cockle	Yellow Nutsedge	Rough Fleabane	Crabgrass	Yellow Nutsedge	White Top
2.	Fall Panicum	Fall Panicum	Crabgrass		Milkweed		Fall Panicum	Fall Panicum	Fall Panicum	Fall Panicum	White Cockle	Cheat
3.									Yellow Nutsedge		Fall Panicum	Bedstraw
4.									Giant Foxtail			
5.									Galensoga			

Title: Forage-Livestock Systems for Land with Soil and Site Limitations

Leader: D. W. Koch (University of New Hampshire)

On a Hollis fine sandy loam soil with species consisting of Dactylis glomerata, Stellaria graminea, Agropyron repens, Barbarea vulgaris, and Trifolium repens, in decreasing order, birdsfoot trefoil seeded by minimum tillage on May 24, 1978, established poorly. Ten weeks after seeding, birdsfoot trefoil represented less than 5% of total forage with all treatments. Seedling counts of red clover three weeks after a May 24 minimum-tillage seeding varied from 18 to 30 per $0.1m^2$. Red clover seedling counts of plots receiving broadcast paraquat at seeding were higher than those with banded paraquat, which were similar to seeded plots with no paraquat. Plots without paraquat were mowed closely three times before and once after seeding. Red clover proportion of the August 6 harvest was highest with broadcast and lowest with no paraquat at seeding. Forage dry matter yield was highest with banded and lowest with no paraquat. Banded phosphorus at seeding slightly reduced seedling counts, had no effect on total yield (August 5), but increased the proportion of red clover in the August 6 harvest. Furadan and the residual herbicides, HuFe 23408 and 2,4-DB, applied after seeding, increased red clover yields at the first harvest. The insecticide increased the total yield, but the residual materials did not affect total yield.

Title: Post Establishment Year Comparisons of Conventional and Minimum Tillage Seedings of Alfalfa into Quackgrass

Leaders: D. W. Koch and G. W. Mueller-Warrant (University of New Hampshire)

Saranac alfalfa (Medicago sativa L.) was established in a predominantly quackgrass (Agropyron repens L.) sward on a Charlton loam soil by conventional (plow, disk, cultipack seed) and minimum (mow, Powr-till seed) tillage techniques on each of 3 seeding dates in 1977 (May 6, May 21, June 4). Herbicide treatments employed were glyphosate 2.2 kg/ha applied May 2 or May 16, EPTC (conv.) or paraquat (min.), and untreated controls. Forage harvests in 1977 and 1978 were analyzed for dry matter yield, crude protein % and yield, ADF, and component yields of alfalfa, grass, and broadleaf weeds, based on both visual ratings and separated subsamples. Regression analysis of 1978 dry-matter yields indicated a positive response to early seeding in 1977, as well as a response to 1978 species composition. Based on 1978 protein and dry matter yields, EPTC provided a sufficient level of quackgrass control for conventional seedings, while glyphosate was necessary for best results using minimum tillage. Dry matter yields in 1978 for minimum tillage were similar to those for conventional tillage for May 6 and May 21 seedings following glyphosate treatment, but were lower for the June 4 seedings.

Title: Annual and Perennial Weed Control in Corn and Forages

Leader: Nathan L. Hartwig (The Pennsylvania State University)

Fall panicum, Panicum dichotomiflorum, control in no-tillage corn was close to 100 percent with post emergence treatments of atrizine + cyanazine at 1.68 + 2.24 kg/ha, atrazine + pendimenthalin at 1.68 + 1.68 kg/ha and cyanazine + pendimenthalin at 2.24 + 1.68 kg/ha. Treatments were made at the 5-6 leaf stage of corn when fall panicum was in the 2-3 leaf stage. There was no apparent injury to the corn from pendimenthalin as had been noted in previous studies when it was applied at or just prior to planting. These same treatments applied early post emergence when corn was in the spike stage and fall panicum was just germinating failed to give 25 percent control. Adequate fall panicum foliage and foliar absorption was apparently necessary for good control.

Effectiveness of butylate incorporation was determined for different tillage tools in conventional and minimum-tillage corn. Effective incorporation following plowing was obtained with the cultimulcher, tandem disk, and roterra. The spring-tooth harrow was less effective. The tandem disk and roterra were also the best implements for incorporation following a chisel plow or a heavy disk. The heavy disk itself gave very poor incorporation.

SECTION VI

MANAGEMENT AND PRODUCTION RESEARCH

Title: Alfalfa Variety Trials

Leaders: L. R. Vough, J. H. McNemar, and N. A. Clark (University of Maryland)

Yield data were obtained for the third year from varieties established in spring 1976. Total dry-matter yields from four cuttings in 1978 ranged from 11.7 to 14.6 mt/ha. The varieties Olympic, Fame, WL311, Atlas, Arc, Victor, R/A 3, Saranac AR, and WL219 yielded significantly more than the varieties Lancer, Gladiator, 521, Apollo, WL318, 530, and Williamsburg.

Olympic, Atlas, Fame, Saranac AR, Victor, Arc, R/A 3, and WL311 also have significantly higher total yields for the three years than do the other varieties. The 3-year total yields ranged from 28.9 to 33.1 mt/ha.

Another alfalfa-variety trial was established in spring 1978. Twenty-three varieties are being evaluated in this trial. Yield data were not obtained during the establishment year.

A trial established in 1973 is being observed for longevity of stands. Twenty-four varieties were established initially, but stands of many of the varieties have either thinned or completely disappeared. No yield data are being collected on these varieties at the present time.

Title: Alfalfa: Competition and Yield

Leaders: N. J. Chatterton and G. E. Carlson (Beltsville Agricultural Research Center)

Breeding programs, as well as physiological studies, often involve the use of spaced plants. We asked what effect plant spacing might have on the rank-order of alfalfa clones selected for yield at one level of competition when grown at another. We grew seven alfalfa genotypes that were known to differ in yield at a density of 13 plants m^{-2} (1 plant sq ft^{-1}) at 13 different levels of competition ranging from about 1 to 100 plants m^{-2}. We assumed that the yield ranking of an individual genotype within a group of genotypes would vary with the level of competition if there were differences among the genotypes in their tolerance to competition. We found that the ranking of the seven genotypes used was essentially the same at all levels of competition. Mean yield across all genotypes was highest (16 mt/ha) at approximately 75 plants m^{-2} (7 plants sq ft^{-1}). Our results suggest that the relative yield per plant among genotypes does not change significantly with level of competition.

Title: Contribution to Forage Yield of Alfalfa, Red Clover, and Birdsfoot Trefoil in Mixture with Grass

Leaders: W. C. Templeton, Jr., and R. R. Hill, Jr. (U.S. Regional Pasture Research Laboratory)

In late April 1978 'Arc' alfalfa, 'Arlington' red clover, and 'Viking' birdsfoot trefoil each were seeded alone and at four rates with either 'Pennlate' orchardgrass or 'Climax' timothy. The grasses were also seeded alone and fertilized with 0, 75, 150, 225, or 300 kg/ha N as ammonium nitrate in two applications. Grown with orchardgrass, alfalfa and red clover seeded at 5.7 and 7.2 kg/ha, respectively, produced as much weed-free forage as the grass with 300 kg/ha N. Birdsfoot trefoil was less productive, a seeding rate of 13.4 kg/ha being required to equal the yield of orchardgrass receiving 150 kg/ha N.

Timothy was much less productive than was orchardgrass, both in pure seeding and with legumes. Seeding 2.5 and 2.1 kg/ha of alfalfa and red clover, respectively, with timothy produced as much weed-free forage as did the grass given 300 kg/ha N. Timothy and trefoil at 7.2 kg/ha yielded more than the grass with 300 kg/ha N. Both alfalfa and red clover decreased forage weed content when seeded with orchardgrass, but trefoil did not. With timothy, each of the legumes effectively reduced weed growth.

Title: Integration and Evaluation of Forage Production, Handling, and Utilization Systems

Leaders: D. P. Knievel, E. J. Partenheimer, and W. L. Kjelgaard (The Pennsylvania State University)

The objective of this regional project is to incorporate literature information about forage production, forage handling and storage, and forage utilization in dairy production systems into an overall forage systems model. The model is to be used to systematically evaluate a range of crop management-dairy nutrition alternatives in dairy production systems where all aspects of the system are included in the evaluation. To do this, the dairy system is divided into management units or subsystems such as crop establishment, crop production, forage storage, dairy nutrition, etc. Activity and economic budgets are developed for each management alternative within each subsystem. All subsystems including alternatives within subsystems are then evaluated simultaneously using linear programming techniques.

Several revision cycles of a forage-dairy systems model have occurred. The present version is designed for a small-farm dairy system (120 acres tillable, 45 milking cows) where alfalfa hay and silage, and corn silage and grain are the principal crops. A unique feature of this model is

that it incorporates dairy nutrition and ration balancing considerations into the overall analysis.

Our results to date indicate that corn for silage should be allocated to better quality land while corn grain should be grown on lower quality land within a farming unit. The model also indicates that alfalfa hay or silage for high producing cows should be managed to obtain high energy and, to a lesser extent, high protein forage even at the expense of reduced stand longevity and more frequent establishment. A detailed sensitivity analysis of components of the model is continuing.

Title: Effects of Wintering Brood Cows in a Pennsylvania Woodlot

Leaders: L. L. Wilson, T. W. Bowersox, D. A. Devlin, and P. J. LeVan (The Pennsylvania State University)

Effects of wintering mature beef cattle in a farm woodlot for 70-day trial periods are being investigated. The woodlot was divided into four fenced paddocks, each 0.4 ha in size, and a 0.8 ha control area. Cattle densities of 2 and 6 animals were replicated and randomly assigned to woodlot paddocks. Six similar animals were introduced onto an adjacent non-sheltered, open lot. Differences in cattle weights were recorded at the mid-points and terminations of three wintering trials (1976, 1977, 1978). There were no significant weight differences ($P<0.01$) between woodlot-wintered and open-wintered cattle for 1976 and 1978. However, a significant difference ($P<0.01$) in average weights between sheltered and non-sheltered animals was obtained in 1977. Wind-chill factors during 1977 may have been the determining factor in weight differences. The effect of cattle densities on understory vegetation was also noted. In lots containing six cows, browsing significantly ($P<0.05$) reduced the abundance of tree seedlings. Shrubby stems were significantly reduced ($P<0.05$) in only one lot containing six cows. Herbaceous vegetation was not significantly affected by either cow density. Soil bulk density increased during the periods of actual use for two of the three project years, but soil density lessened during times of cattle exclusion.

Title: Responses of Perennial Legume Varieties to Management

Leaders: W. C. Stringer and K. T. Leath (The Pennsylvania State University and U.S. Regional Pasture Research Laboratory)

Six alfalfa varieties (Arc, Saranac, Saranac AR, Dekalb 131, Iroquois, and WL 311) were established in the summer of 1978 at Rock Springs. Plant samples were taken at weekly intervals throughout the autumn season. Arc and Dekalb 131 showed greater autumn yields than other

varieties but had fewer crown buds in autumn. These plots will be subjected to five management systems including simulated rotational grazing, 4-harvest, and 5-harvest systems starting in the spring of 1979.

A similar trial for red clover varieties was seeded in the spring of 1978 but suffered severe ice-sheet damage in the winter of 1979. This will be reseeded.

In another trial Saranac AR and Victor alfalfa will be harvested in 1979 according to schedules that will allow final cutting dates in early, middle, and late September and mid-October. Regrowth periods of 28, 35, and 42 days before the autumn harvest will be part of the treatments. The objective will be to investigate the effects of fall cutting management on alfalfa morphology, physiology, and yields.

Title: Effect of Lime and Phosphorus on Legume Growth and N Fixation

Leaders: G. O. Estes and D. T. Roberts (University of New Hampshire)

Low soil pH and Al toxicity are significant factors governing the adaptability and persistence of forage legumes on many soils of Northeast dairy farms. Increased use of no-till establishment methods with surface liming and fertilization provides incentive for new research on soil behavior and plant response to these amendments.

Greenhouse studies with three soils having widely differing levels of exchangeable Al are underway to determine the effect of P, dolomitic limestone, and hydrated lime on root development, N fixation, and yield of alfalfa along with soil pH and levels of Al and P. Reduction of soil Al is effectively and rapidly done with P additions; dolomitic limestone is extremely slow-acting; without an initial lag period, use of hydrated lime results in P deficiency.

Field studies initiated in 1978 are designed to determine the effectiveness of superphosphate and various liming materials in altering soil Al and P within the soil profile of no-till and conventionally tilled plots seeded to alfalfa and red clover.

Title: Productivity and Quality of Fertilized Perennial Forages

Leader: L. E. Lanyon (The Pennsylvania State University)

Crownvetch (CV) response to fertility and management was studied in this project. The experiments were on a Hagerstown silt loam soil in Centre County, Pa.

There was no response to applications of 24 and 48 kg/ha P; 93 and 186 kg/ha K or 134 kg/ha Mg by an established CV stand. Harvesting the CV at early bloom and then 9 weeks later provided the most uniform distribution of forage. Herbicide applications were necessary to maintain stand purity.

Orchardgrass (OG), tall fescue (TF), timothy (T), and smooth bromegrass (BG) were easily established in an existing CV stand. OG and TF established most rapidly and accounted for 70 percent of the stand in the first harvest within two years. T and BG attained similar levels within three years.

CV was established with OG, TF, T, or BG and the grass species were established in pure stands. Treatments included 49 and 93 kg/ha or 98 and 186 kg/ha of P and K. N was applied in the spring and/or after the first cutting in 56 kg/ha increments. The contribution of CV to yield and crude protein varied with the percentage of the stand. Mixed stands with 20-25 percent CV were equivalent to 112 kg/ha N. N applied to the mixed stands decreased the CV content from 15 percent in the first harvest and 40 percent in the second to 10 and 20 percent respectively. Yields from the stands were not affected by added N. Liquid manure at 112 kg/ha N could substitute for N fertilizer but was only 40 to 50% as effective.

Title: Hay and Silage Investigations

Leader: Milton A. Sprague (Rutgers University)

Investigations continued on the development of a small, quick-reading dependable meter to determine the moisture content of hay in the field prior to baling. New hay making methods, including the use of organic acids to prevent mold at higher moisture contents, require that the meter be reliable and accurate in the 25 to 35% range. In 1977 studies indicated that uniform and reliable readings depend largely on a sensor head specially designed to represent species and mixtures of forages with different textures and physical compositions.

In 1978 five differently designed sensing electrodes were tested extensively on several grass and legume hays. Statistical comparisons indicated one design was superior to others when compared to oven dried samples. A newly designed sensor incorporating the desirable features of all the experimental types will be constructed for calibration and field use in 1979.

Title: Forage-Livestock Systems for Land with Soil and Site Limitations

Leader: Milton A. Sprague (Rutgers University)

Seed of 14 selected warm-season grasses and 9 promising clovers were obtained through the regional forage project NE114 for planting on two areas with soil and site limitations. Due to weather and other problems, planting was delayed until August 12, 1978, on sandy loam soil at the Adelphia Research Farm. Germination and emergence were excellent, but subsequent growth was varied and poor, mostly due to inadequate weed control. Further evaluations will be made during 1979.

Breeders planting stock of Tifton-44 bermudagrass was established as an isolated increase block at the Adelphia Research Farm. This new variety holds considerable promise of improved yield, quality, and winter survival on the difficult sandy soils of southern New Jersey and will be planted on test sites as support for evaluation permits.

Kenland and Kenstar red clovers (sown in '77) yielded the most at 8.7 mt/ha each in 2 cuttings and Florex the least (7.6 t/ha) of 5 varieties tested. Over a 3-year period, Arc and Saranac AR alfalfas were superior to others tested. Stands of all 10 varieties have remained adequate. WL 201 and Arc showed least weevil damage; all varieties were similar in protein.

Title: Soil-Plant-Environment Relationships in the Productivity and Quality of Forages

Leaders: W. C. Stringer and L. A. Lanyon (The Pennsylvania State University)

In studies of the methodology of extracting acid-soluble, or nonexchangeable (NE), basic cations from soils, the magnitude of Ca, Mg, and K released with time was 1N HCl (boiling) > 1N HNO_3 (boiling) > 10 ml concentrated H_2SO_4+25 ml H_2O > 10N H_2SO_4 > 1N NH_4OAc, pH7. For Mg and K exponential release occurred through 1 to 4 hours boiling time; linear release continued from 4 to 16 hours. Release of Ca was relatively independent of time. Increasing the solution:soil ratio of 1N HCl (boiling) extractions was found to promote cation release. The 1N HCl (boiling) extract with solution:soil ratio of 3.5 and boiling for 4 and 16 hours was selected to evaluate NE basic cations from five soils. Exchangeable (E) cations were extracted with 1N NH_4OAc, pH7.

The range in E cations was from (meg/100g): 0.4 to 6.5 Ca, < 0.01 to 1.3 Mg and < 0.01 to 0.46 K. At 16 hours NE cations ranged from (meg/100g): 0.2 to 11.3 Ca, 0.60 to 28.0 Mg, 0.16 to 1.56 K. Absolute

and relative quantities and release from soil reserves of NE basic cations may be significant to fertility requirements and seasonal patterns of nutrient uptake by plants.

A field study on Hagerstown silt loam soil was initiated in fall 1978 on effects of timing of applications, and sources and rates of P and K fertilizer on alfalfa yield, chemical composition, and nutrient removal and changes in soil levels of these nutrients. The nutrients were applied as either concentrated superphosphate, KCl, or K_2SO_4 at rates of 0, 0.5, 1, or 2 times the recommended soil test rates as all-at-planting, an annual application, or a split annual application.

Title: Effect of Magnesium Fertilization on Timothy Yield and Mineral Composition

Leaders: B. S. Baker and R. L. Reid (West Virginia University)

An established stand of timothy was fertilized in early spring 1978 with 400 kg Mg/ha, applied as $MgSO_4$. Samples were collected weekly for mineral analysis. Magnesium fertilization did not increase yields. Magnesium fertilization nearly doubled Mg concentration at all stages of growth with the highest concentration being 0.21%. Sulphur concentration increased slightly, but concentrations of other minerals were not affected by Mg fertilization. Magnesium, phosphorus, potassium, and calcium all tended to decrease in concentration as plants became mature. At anthesis, plants were separated into leaf, stem, and head fractions. Leaves were found to contain twice as high a concentration of Mg as the stems. Heads were similar to leaves in mineral concentration. Crowns from treated plots were found to contain 0.04% Mg and those from control plots contained 0.02%.

Title: Forage Yield Determinations of Mixed Swards Using a Disk Meter

Leaders: B. S. Baker, T. V. Eynden, and N. Boggess (West Virginia University)

Disk-meter readings and dry-matter yields from clippings were taken on a number of mixed swards used for hay production. The swards were characterized according to species composition and growth stage. Formulas were developed to use with disk-meter readings as a means of determining forage yield. Analyses indicate that yields can be predicted from disk-meter readings within 90% of yields determined by clippings when adjustments are made for quadratic functions and different types of forage.

Title: Nutrient Utilization Efficiency of Crop Species, Hybrids, and Cultivars

Leaders: R. H. Fox and R. J. Morris (The Pennsylvania State University)

Eighteen varieties of warm-season grass species (little, big, Old World, and Caucasian bluestem; Indiangrass, Tioga deertongue grass, and switchgrass) and four cool-season species (orchardgrass, tall fescue, crownvetch and flatpea) were grown in a replicated trial on a Berks shaly silt loam at two available soil phosphorus levels (7 and 60 ppm Bray 1 extractable P). Other nutrients were supplied at optimum levels. The experiment was established in 1976. All species were harvested in the early heading stage and at the end of the growing season in October. This resulted in three harvests for the cool-season species and deertongue grass, two for the switchgrasses and bluestems, and one for Indiangrass.

Total yields in 1978 on the high-P soil ranged from 174 g/meter row (crownvetch) to 1,316 g/meter row (Caucasian bluestem). The highest yielding cultivars were Caucasian bluestem, Carthage switchgrass, NJ-1617-72 Indiangrass, Blackwell switchgrass, and NY 4598 switchgrass. On the low-phosphorus soil total yields of the cultivars ranged from 126 g/meter row (crownvetch) to 1,102 g/meter row (Caucasian bluestem). The highest yielding cultivars in the low-P soil were Caucasian bluestem, KY 729 switchgrass, Blackwell switchgrass, and Old World bluestem, respectively.

On the low-P soil there was a large range in P concentration among cultivars ranging from 0.067% P in the Caucasian bluestem to 0.197% P in Lathco flatpea, with an average of 0.091% in the warm-season species and 0.165% in the cool-season species. Phosphorus concentration in the plants grown in the high-P soil ranged from 0.115% in Camper little bluestem to 0.326% in Lathco flatpea.

On the low-P soil total P uptake ranged from 255 mg/row with crownvetch to 858 mg/row with Ky 729 switchgrass with an average of 746 mg/row for the four highest warm-season species and 427 mg/row for the cool season species. Total P uptake by plants grown on the high-P soil was approximately twice that in the low-P soil, ranging from 423 (NY 4006 switchgrass) to 1,772 mg/meter row (Caucasian bluestem) with an average of 1,417 and 935 mg/meter row for the four highest warm- and cool-season species, respectively.

This year's results indicate that, although low in P concentration, KY 729 switchgrass, Caucasian bluestem, Old World bluestem, Blackwell switchgrass, and NJ 1617-72 Indiangrass will produce higher dry-matter yields and have a greater total P uptake on a soil which is low in available P than will the other cultivars tested. While flatpea, crownvetch, orchardgrass, tall fescue, and deertongue grass have a higher P concentration, their yields and P uptake are relatively low.

Title: Producing Dried Immature Forages as Grain Substitutes for Ruminants

Leaders: R. F. Stafford and R. G. Hall (University of Maine)

Small-plot, harvest-schedule studies with pure stands of alfalfa and timothy, which were established in 1976, were continued.

The alfalfa study was managed to produce immature forage (early bud stage) at different periods of the season (early June, mid July, late August). Mature harvests (mid to full bloom) were utilized to restore plant vigor following each immature harvest. The timothy study was similarly planted to produce immature forage (mid to late jointing stage) at different times from June to September.

The immature harvests produced dry matter yields of 600 to 3,350 kg/ha for alfalfa and 743 to 3,837 kg/ha for timothy. The immature alfalfa ranged from 20 to 29% crude protein (d.m. basis), and the timothy from 13 to 20%. Dried samples of these forages were stored for subsequent studies by the animal nutritionist.

Botanical separations made of all harvesting schedules imposed on the alfalfa during 1977-78 indicate that alfalfa persistence is favored by cutting the immature stage at one of the aftermath harvests. However, dry-matter yields may be sacrificed by as much as 2,400 kg/ha. The harvesting schedules have had no effect on timothy stands.

Large plots of pure, immature alfalfa and timothy were produced for pelleting studies conducted by the agricultural engineer. Samples of these were stored for subsequent feeding studies by the animal nutritionist, to compare pelleted versus chopped forage.

Title: Availability of Magnesium from Different Sources Under Field Conditions

Leaders: V. D'Costa, R. F. Keefer, and R. N. Singh (West Virginia University)

An acid West Virginia soil was fertilized with dolomite, MgO, and $MgSO_4$ at 0, 224, 448, and 672 kg Mg/ha to evaluate effectiveness in crop uptake of Mg for proper ionic balance to prevent grass tetany. A field experiment on Berks soil (Typic Dystrochrept) containing established orchardgrass (85%) and tall fescue (15%) was conducted for three years. Soil pH was adjusted to pH 6.5 with surface application of hydrated lime in conjunction with Mg fertilizers followed by light discing. Mg increments significantly increased the Mg concentration in grass. Magnesium sulfate increased the grass Mg level more effectively than

did dolomite or MgO during the first two (dry) years after fertilization. In the third (wet) year, the less soluble fertilizers (dolomite and MgO) maintained a relatively higher grass Mg level than did $MgSO_4$ at higher rates. Generally, the 672-kg/ha Mg rate was necessary to maintain grass Mg concentration above 0.25% for a period of approximately three years, whereas the 224-kg rate was inadequate to maintain the level above 0.20% Mg, critical for grass tetany, beyond two years. Mg increments also resulted in decreasing K and Ca levels and in a more favorable K/Ca+Mg balance, particularly for grass quality on Berks soil with high available K. A decrease in the ratio of K/Ca+Mg is known to decrease the chances of grass tetany. Since response from dolomite and MgO on grass occurred after three years of fertilization, it is essential that this study be conducted during two more years to determine long-term effects.

Title: Development of Seeding Techniques and Management Systems for Feed Crops in Southwestern Pennsylvania

Leader: W. G. Downs, III (The Pennsylvania State University)

No-till seedings of three varieties of alfalfa seeded in 1977 were harvested for hay, with 11.4 mt/ha being harvested in three cuttings. This is the third time in four years that a rotation from grass to corn and back to alfalfa has been completed successfully without plowing or discing. No-till corn was repeated on an adjacent 1.6 hectares using the Bridger planter. Weed and grass suppression was accomplished with 1.65 kg a.i./ha of atrazine + 1.65 kg a.i./ha simazine + 0.55 kg/ha paraquat + 0.275 kg/ha of dicamba. A problem weed, Physalis heterophylla, necessitated the dicamba. A 0.8-ha wet field was successfully sod seeded with a Tye drill to reed canarygrass, Phalaris arundinacea, following a 1977 corn crop. In addition, 9.6 ha of alfalfa and 0.8 ha of birdsfoot trefoil-timothy mixture were successfully seeded with the same implement. Birdsfoot trefoil sod seeded into an old orchardgrass stand with the Tye drill was moderately successful. Orchardgrass is highly resistant to suppression by paraquat and offers excessive competition to birdsfoot trefoil seedlings in its regrowth. The Tye drill offers flexibility over the soil surface but caution must be used to avoid deep placement of seed in moist soil or through over weighting.

Title: Forage-Livestock Systems for Land with Soil and Site Limitations

Leaders: R. C. Wakefield and J. D. Stich (University of Rhode Island)

Adaptation studies were initiated with 12 species of grasses and legumes on an Agawam fine sandy loam. Emergence and stand-count data indicated successful establishment of all species on the droughty, infertile soil.

Establishment studies were initiated with red clover and birdsfoot trefoil, sod-seeded into an old timothy stand. Treatments included two herbicides, phosphate fertilizer, and an insecticide. Establishment of red clover was satisfactory with either band or broadcast use of paraquat, while stands of birdsfoot trefoil were superior with the broadcast treatment. Phosphate fertilizer did not aid establishment of either species, but the insecticide was important in establishment of both legumes.

Title: Effect of Nutrition on Early Development of Corn

Leader: G. O. Estes (University of New Hampshire)

Studies to evaluate the effects of culture and nutrition on early development of corn under sub-optimal temperatures continue. Analyses of three crops from 1976, 1977, and 1978 showed that splitting the total N application of 202 kg N/ha did not significantly increase seedling growth, the rate of leaf-area development or yield of silage corn compared with an incorporated pre-plant N application. Losses of broadcast-applied urea on no-till corn were as high as 35%, compared with conventional tillage where urea was incorporated; total plant absorption of N from ammonium nitrate was significantly higher than from urea on no-till plots. Tissue analyses of both research-farm and dairy-farm samples of corn silage show extremely low levels of S with values as low as 0.03% S observed in several cases.

Title: Flexible Forage Production and Utilization Systems for Pennsylvania's Varied Environments

Leaders: K. T. Leath and W. C. Stringer (U.S. Regional Pasture Research Laboratory and The Pennsylvania State University)

An alfalfa autumn management experiment was terminated after a third harvest. Harvest yields and previous counts of crown buds and non-structural carbohydrates are being summarized at present. An experiment was started in autumn of 1977 to compare longevity and yields of red clover stands seeded in April vs. August. Arlington planted in autumn 1977 yield 10.4 mt/ha in 1978 compared to 8.5 for spring 1978 seeding ($P>0.05$) Pennscott yielded 9.0 mt/ha for fall seedings compared to 8.8 for spring seedings (NS). Fall 1978 stand counts were not different for varieties or for fall 1977, spring 1978, or fall 1978 seeding dates.

An alfalfa variety x management interaction study has been established in central Pennsylvania and on the Allegheny Plateau (north central Pa.). Five different management programs will be imposed on these varieties. A similar experiment with red clover has been established at the same locations. Seeding year yields of red clover varieties at State College (2 harvests) showed Arlington to yield significantly less than Redman (7.01 vs. 7.56 mt/ha). A grass species and variety trial has been established at Landisville (S.E. Pa.), Rock Springs (central Pa.), and the Plateau location. Growth-stage dates will be recorded and spring, summer, and fall growths sampled for yield and *in vitro* nutritive value.

Title: Comparison of Methods of Legume Establishment in Hill Pasture Under Rotational Grazing

Leader: W. B. Bryan (West Virginia University)

Use of two sod-seeders and broadcast planting of red clover, white clover, and birdsfoot trefoil are being compared under two herbicide and two fertilizer treatments. All plots are being rotationally grazed in one field, and establishment, botanical composition, and persistence are being assessed visually. Use of paraquat increased the number of legume seedlings significantly, whereas P and lime application had no significant effect on seedling number. Both use of paraquat and P and lime application increased the percent legume in the plots and sown legumes were also more vigorous. Although broadcasting the legume seed resulted in significantly fewer seedlings than use of a sod-seeder, legume stand and contribution of the legume to the sward were not different compared with the zip seeder.

Title: Forage-Livestock Systems for Land with Soil and Site Limitations

Leaders: A. M. Decker, R. F. Dudley, H. T. Badger, and W. E. Beers (University of Maryland and Beltsville Agricultural Research Center)

'Kenstar' red clover and 'Empire' birdsfoot trefoil were used in a sod-seeding study (19 treatments) to evaluate fertilizer placement, residual weed control, insecticide, and band vs. broadcast application of paraquat. Treatments were seeded in both spring and fall. Stand counts were made approximately 30 days after seeding. Stand ratings were made at 30 days and again in late fall, going into winter. Forage yields will be determined in 1979. There was a small, non-significant, advantage for band placement of P with little benefit for either an insecticide or residual herbicide. Fewer weeds were present with banded paraquat than with broadcast paraquat. All seedlings are scheduled to be repeated in 1979.

Title: Effect of Management Factors on Alfalfa Productivity and Persistence

Leader: W. C. Stringer (The Pennsylvania State University)

In a K rates x alfalfa varieties experiment in SE Pennsylvania where 4 K_2O rates (0, 134, 269, 403 kg/ha) were applied at seeding in April, 1975, 4 alfalfa varieties failed to show favorable total yield responses to higher K_2O rates in 1977. However, in the first-harvest yields (June 3) the two highest K rates caused significant yield increases. Saranac AR and Arc (anthracnose resistant) were not better yielders than Saranac but all three were superior to Team. Soil tests taken in autumn of 1977 indicated uniform, adequate plant-available K under all fertility rates. The total yields of the first two harvests of 1977 averaged 3.34 tons. In an autumn harvest x alfalfa varieties trial at Rock Springs, harvesting during the first 3 weeks of September caused lower total forage yields and generally lower first-cut yields the following year. Later autumn cuttings caused less depression of first-cut yields. The WL-311 variety gave higher yields and did not suffer as much from the September harvests as did Iroquois, Saranac AR, and Arc.

Title: Evaluation of Sod-seeded Pastures Using Dairy Steers and Heifers

Leaders: A. M. Decker, J. H. Vandersall, and W. E. Beers (University of Maryland)

During the last week of August and first week of September, 1977, experimental pastures were sod-seeded with the following treatments: (1) alternate rows of red clover with birdsfoot trefoil-ladino clover; (2) alternate rows of red clover with crownvetch-ladino clover; (3) alternate rows of red clover with ladino clover. Extended severe drought following seeding resulted in complete stand failure of all seeded species. All paddocks were reseeded April 7-11, 1978, using a John Deere Powr-Till seeder with a 10-cm band of paraquat sprayed over each row at seeding. All paddocks were clipped once to control growth of existing vegetation. Experimental grazing started June 20 using dairy heifers and steers. Grazing was terminated October 6, 1978. Most pastures were ready to be grazed much earlier than June 20; however, in order to have more uniform growth at the beginning of the study, the delay seemed justified. Pasture carrying capacity, liveweight gain per hectare, and average daily gains were good to excellent and similar on all pasture treatments. Liveweight gains varied from 187 to 214 kg/ha. Pastures are scheduled for full-season grazing during 1979 and 1980. In addition to animal performance and pasture production, stand longevity will be determined.

Title: Red Clover Variety Trials

Leaders: A. M. Decker and W. E. Beers (University of Maryland)

Sixteen varieties and strains of red clover were seeded at four locations in spring 1978. Locations ranged from the Coastal Plains area of the Eastern Shore to the mountains of western Maryland. Good to excellent stands were obtained at all locations, but no harvests were made in 1978. Stand ratings made at the end of the growing season showed only minor differences between entries. Two to four forage harvests will be made during the 1979 growing season. All entries will be rated for stand persistence and vigor. Those varieties that persist will be harvested at least one more year.

Title: Forage Production and Quality Evaluations

Leaders: A. M. Decker, R. F. Dudley, and W. E. Beers (University of Maryland and Beltsville Agricultural Research Center)

A series of small-plot, sod seeding studies were initiated in fall 1977, but because of the severe fall drought, all studies had to be terminated and no data were collected in 1978. In one of the multiple species studies, only stands of red clover approached satisfactory condition by early spring of 1978. By fall 1978 most trefoil plots exhibited good stands; apparently enough hard seeds survived the winter and spring germination to produce these stands. This pattern for red clover and trefoil has been observed in other years. An experiment comparing the John Deere Powr-Till, Melrose, and Zip sod-seeders was reseeded in the spring of 1978. Excellent stands of red clover were obtained with each machine while alfalfa stands were generally poor with all machines. Forage yields on these plots will be determined in 1979. A sod seeding study was established in spring 1978 to evaluate four forage mixtures and two fertility levels on adjacent level and hill-land locations. Good stands were obtained and forage yields will be determined in 1979.

Title: Supplemental Protein for Gestating Beef Cows Fed Corn Residue

Leaders: W. E. Kunkle, E. C. Leffel, and J. Buric (University of Maryland)

Corn-residue stacks, corn-residue grazing, and conventional-hay feeding were compared as feed systems for gestating beef cows in the winter (Dec.-Jan.) of 1978-79. The corn-residue stacks were supplemented with a 30% crude protein (C.P.) liquid supplement (1.95 kg/hd/day), 43% C.P.

soybean meal (0.45 kg/hd/day), 16% C.P. alfalfa hay (1.36 kg/hd/day), or not supplemented (controls). The cows grazing corn residue were fed hay during snow cover (0.64 kg/hd/day) and the cows fed conventionally were grazed on residual pasture and fed supplemental hay (alfalfa-grass, 5.77 kg/hd/day). All cows were provided a complete mineral supplement with Vitamin A.

The corn-residue stacks were harvested in mid-October and analyzed (dry matter): 6.4% crude protein, 46.7% acid detergent fiber, 0.51% calcium, 0.17% phosphorus, 0.23% magnesium, and 1.11% potassium.

The cows (10-12/treatment) fed conventionally and those grazing corn residue gained weight (0.47 and 0.13 kg/hd/day respectively), but those fed corn-residue stacks lost weight during the 56-day trial. The cows fed corn-residue stacks supplemented with liqued supplement, soybean meal, alfalfa hay, or controls lost 0.32, 0.17, 0.39, and 0.71 kg/hd/day respectively. The natural protein and urea-based protein supplements gave similar results, in contrast to results of a similar trial two years ago. The cows losing weight had more variability in performance on the same treatement than those gaining weight.

Results of a similar trial two years ago indicated no differences in percent calving, birth weight, calf mortality, weaning weight, and calving interval between treatments. Several of the cows lost over 100 pounds prior to calving but this did not affect their performance. The cows were in good flesh at the start of the trial.

Our studies indicate that corn residue stacks may need to be supplemented with energy as well as protein to maintain the gestating beef cow during the winter.

Title: Forage Variety Tests

Leader: W. W. Washko (University of Connecticut)

Tests of alfalfa, red clover, and perennial cool-season grass varieties and experimentals from both experiment station and commerical sources are being conducted to evaluate yield and persistence. Corn varieties are evaluated for silage yields.

Alfalfa and red clover data are reported through the Eastern Forage Improvement Conference. The Iroquois and Saranac varieties of alfalfa are the standard persistent and high performance types, respectively, against which others may be compared.

Title: NE 114--Forage-Livestock Systems for Land with Soil and Site Limitations

Leader: W. B. Bryan (West Virginia University)

Red clover and birdsfoot trefoil were sod-seeded into a Kentucky bluegrass, white clover, redtop pasture with different herbicide, fertilizer, lime, and insecticide treatments. The site is on a 15% slope Culleolka-Westmoreland soil, pH 4.8 and soil P 24 lb/ac. Plots were seeded in spring and fall. In the fall, spring seeded plots were estimated to have 68% legume on red clover plots and 29% on birdsfoot trefoil plots. Yield in two harvests was 2,505, 1,893, and 1,600 lb/acre on red clover, birdsfoot trefoil, and non-seeded, fertilized and limed plots, respectively. Within seeded plots, no addition of lime reduced yields and percent legume whereas no addition of P had little effect.

Title: Weed Control with Broadcast Seeded Forage Varieties of Turnips, Swedes, Rape, and Sugar and Fodder Beets

Leaders: V. Ulrich and G. A. Jung (West Virginia University and U.S. Regional Pasture Research Laboratory)

Broadcast seedings of a number of varieties of turnip, swedes, rape, and sugar and fodder beets were made during 1978. Nitrogen fertilizer was applied at the rate of 67 kg/ha. Potassium and phosphorus were present at adequate levels; the soil pH was 6.5. Preemergence application of Treflan and Pyramin provided adequate control of annual grasses and broadleaf weeds in the Brassica crops. However, the lack of growth, vigor, and competition of the foreign introductions resulted in a considerable weed problem after several months when the herbicides had been depleted. Dasanit, Disystone, Monitor, Nemacur, and Furadan applied preemergence as recommended were effective in reducing insect damage on all varieties and species of the Brassicas. However, the foreign root crop introductions did not respond differently from the previous year, or from the controls, in spite of the pest control measures taken. The lack of growth and vigor is most likely attributable to lack of adaptation in this area and probably not to soil insect or nematode damage. Superficial examination did not provide evidence of the presence of fungal or bacterial pests as causal agents.

Preemergence application of Ro-Neet, according to manufacturer's recommendations, provided excellent weed control in broadcast sugar and fodder beets.

Title: Production Efficiency and Quality of Forages for Increased Use in New England

Leaders: D. W. Koch, G. O. Estes, and G. W. Mueller-Warrant (University of New Hampshire)

Conventional seedings of alfalfa-orchardgrass and birdsfoot trefoil-timothy established more quickly and responded more favorably to lime application than minimum-tillage seedings of the same mixtures into Bromus arvensis sod. There was no species by establishment method interaction with respect to yield. Yields of legume, total forage, and protein the seeding year were higher for conventional than for minimum-tillage establishment. The year following establishment, forage dry-matter and protein yields were similar for both methods of establishment. Yields of birdsfoot trefoil were greater than those of alfalfa with no lime and soil pH of 5.6 at seeding. Lime application at 4.5 t/ha increased forage yields the seeding year approximately 1 ton/ha. The alfalfa/orchardgrass mixture responded more favorably than birdsfoot trefoil-timothy to 4.5 t/ha of lime. Both establishment methods responded similarly. There was no significant yield increase during the establishment year with 9.0, compared to 4.5, t/ha of lime.

SECTION VII

ENGINEERING RESEARCH

Title: Processing Dried, Immature Forage as Grain Substitutes for Ruminants

Leader: R. J. Rowe (University of Maine)

First cut alfalfa plots were cut on June 5 at bud stage. Following approximately 2 days of field drying in sunny but cool weather, the wilted forage was chopped at 65% moisture content (wet basis). The chopped alfalfa was dried in bulk at about 3.5 ft. depth with 30 cfm per square foot of air. Air was heated by a solar air heater with from 10 to 15 degrees F increase in temperature during mid-day. Total drying time to 13% moisture content was approximately 4.5 days including two days of rain. Approximately 753 kg of forage was stored for subsequent feeding trials.

First-cut timothy plots were harvested June 15 at mid- to late-boot stage. Field drying of one day resulted in chopping at 62% moisture content. The chopped timothy was dried using the same technique as with alfalfa. Approximately 533 kg of the timothy was stored at 13% moisture content after 5 to 6 days of drying, using solar heated air.

Input data were prepared for the NE-111 comprehensive forage-system-analysis model. Equipment was selected by type and size, and machine operating times and fuel requirements were estimated for the various field operations. These and other cost data used in the model were reviewed and adjusted to correspond to northern New England conditions.

Title: Microbial Conversion of Solid Wastes in Plant Protein Recovery

Leaders: R. E. Mudgett and P. L. Pellett (University of Massachusetts)

Pressed cakes obtained in mechanical extraction of plant protein are being investigated as a source of improved non-ruminant animal feed by microbial conversion of plant solids to fungal biomass of high protein content and reduced bulk in fermented form. The process being considered is solid-state fermentation by means of aerobic degradation of plant polysaccharides normally indigestible by non-ruminants. Aerobic biomass yields are considerably higher than anaerobic (rumen) yields in terms of energy production in microbial metabolism and are expected to yield 4-5 times the biomass production obtained in anaerobic processes without production of organic acids which cannot be converted to the essential amino acids in mammalian metabolism. Preliminary results in submerged culture studies suggest conversion of 70% of plant solids of microbial biomass with a reduction in bulk of the fermented solids of 35% when the press cakes were supplemented with nitrogen and phosphorus. Nitrogen was supplied as urea. Nutritional quality of the fermented solids is currently being evaluated in terms of amino-acid composition.

Title: Solid-state Fermentation Processes in Plant Protein Recovery

Leaders: R. E. Mudgett, P. L. Pellett, and R. Rufner (University of Massachusetts)

Solid-state fermentation studies for protein recovery from alfalfa in controlled gaseous environments have been completed. High levels of oxygen and carbon dioxide were found to enhance protein recovery, partially due to oxygen limitation in enzyme (cellulase-pectinase) and biomass production at the expense of alfalfa solids. Recoveries of nearly 70% of total protein contents were obtained in a controlled gaseous environment at high oxygen-transfer rates. A model system for production of amylase in controlled environments also shows oxygen limitations in microbial growth and inhibition at high levels of carbon dioxide. Optimal levels of carbon dioxide were observed for enzyme and biomass production in the model solid-substrate fermentation. Nutritional evaluation of process residues and the nature of fungal growth in solid-state fermentation are also continuing.

Title: Yeast Cultivation on Alfalfa Process Wastes

Leader: R. E. Mudgett (University of Massachusetts)

Fermentations of alfalfa brown-juice waste from mechanical extracts of alfalfa protein gave biomass densities in excess of 20 g/l in submerged culture with 60-70% reduction in dissolved solids. The brown juice was found to be limiting in nitrogen and phosphorus and to give biomass of low protein content without supplementation. Supplementation was found to increase protein content of the biomass to nearly 50% on a dry weight basis and growth kinetics were observed to be diauxic with sequential utilization of carbohydrate constituents believed to include primarily glucose, fructose, and sucrose. Some of the nitrogen in the brown juice was also in a form not available for microbial conversion. Identification of major carbon and nitrogen components before and after fermentation is continuing as a model for food and agricultural waste process design for yeast production.

SECTION VIII

NUTRITIVE EVALUATION AND UTILIZATION

Title: Nutritive Value of Warm-Season Grass Hays for Beef Cattle and Sheep

Leaders: R. L. Reid, G. A. Jung, and W. C. Sharp (West Virginia University, U.S. Regional Pasture Research Laboratory, and Soil Conservation Service, Broomall, Pa.)

Estimates of digestibility, voluntary intake, and mineral utilization of warm-season grass hays are being made with mature, dry beef cows and wether lambs. Initial trials have been run with different varieties and growth stages of switchgrass (13 hays) and big bluestem (2 hays), with first cut (head emergence) tall fescue as control; hays were harvested in Pennsylvania (Western Pa. Forage-Beef Farm and Midla Farm), New York (Big Flats Plant Material Center), Kentucky (Quicksand Plant Materials Center), and New Jersey (Cape May). In trials with 9 hays fed to both cattle and sheep, DMD by cows was significantly higher than for lambs (range of 51.8-74.5% for cows cf. 47.7-66.1% for sheep); highest DMD was obtained with tall fescue. DMD on 16 hays fed to cows ranged from 30.3-74.5%, and intakes from 44.1-125.1 g/kg $BW^{\cdot 75}$, with a positive correlation between DMD and intake. Cattle data indicated marked stage-of-growth and varietal effects on DMD and intake; lesser effects were noted with lambs. Crude protein concentrations ranged from 5.9-10.9% and appeared adequate for cows, marginal for lambs. Levels of P, K, and S were generally low, Ca and Mg adequate. Concentrations of neutral-detergent fiber ranged from 71.4 to 83.0% in the warm-season grasses, compared to 63.9% in tall fescue; acid-detergent fiber values showed a range of 38.7-51.8%. Relationships between chemical composition, *in vitro* digestibility, and digestibility and intake of cattle and sheep are being determined.

Title: Evaluation and Use of Meadow Voles as a Bioassay of Forage Quality and Model for Ruminant Animals

Leaders: R. L. Cowan, T. V. Hershberger, H. Rothenbacher, J. S. Shenk, W. A. Kendall, and W. C. Templeton, Jr. (The Pennsylvania State University and U.S. Regional Pasture Research Laboratory)

The intake of single meals of Kentucky bluegrass, tall fescue, 'Pangola' digitgrass, bermudagrass, and bahiagrass by meadow voles was correlated with some forage chemical constituents to determine their relative importance to the intake process. The grasses grew in their regions of adaptation and were harvested at various stages of maturity. Intake was most closely associated with the fiber components of the forages and to some extent with water soluble or readily digestible nutrients. The voles ate relatively small amounts of species that are generally not consumed well by livestock and, therefore, the technique appears to be useful for further studies with problem forages.

Title: Utilization of Digestible Energy in Cattle

Leaders: H. F. Tyrrell, P. W. Moe, and P. J. Reynolds (Beltsville Agricultural Research Center)

Eight yearling Holstein steers with an average initial weight of 211 kg were assigned to a replicated Latin square experiment to evaluate the effect of formic acid-formaldehyde additive to orchardgrass at the time of ensiling plus the effect of supplementing both untreated and treated silage with a high-quality protected protein on energy and nitrogen balance. At equal intake of gross energy per unit of metabolic body size, energy retention in body tissue was not affected by either forage treatment or silage supplement. Nitrogen retention was increased by both forage treatment and protein supplement from 20 g/day for the untreated silage unsupplemented to 33 g/day for the supplemented treated silage. Thus, increasing the dietary intake of less soluble nitrogen from these hay-crop silage diets results in apparent gain of body tissue containing more energy in the form of protein and less in the form of fat. A study to determine whether the partial efficiency of acetate utilization for body tissue deposition in cattle is dependent on the quantity of acetic acid infused into the rumen yielded inconclusive results, thus emphasizing the need for a more sensitive technique, e.g., radioisotope dilution, for supplementing indirect calorimetry in these studies. Equipment for measurement of radioactive gas in calorimetric studies has been installed and tested.

Title: Sodium Bicarbonate Addition to Corn Silage Rations of Prepartum and Postpartum Dairy Cows

Leaders: L. D. Muller, L. H. Kilmer, and P. J. Wangsness (The Pennsylvania State University)

Many dairy cows are presently maintained on a high forage:low concentrate diet during the dry period and are abruptly switched to a high energy (often corn silage as the forage) diet immediately postpartum. The objective of this research was to study the addition of sodium bicarbonate to complete rations of pre- and postpartum Holstein cows on possible adaptation to high energy rations postpartum.

Forty-five Holstein cows were blocked into groups of three, and two weeks prior to parturition were assigned randomly within blocks to one of three treatment groups: a) control prepartum and postpartum; b) control prepartum, buffer postpartum, and c) buffer prepartum and postpartum. The rations, on a dry matter (DM) basis, consisted of 85% chopped hay:15% concentrate prepartum and 60% corn silage:40% concentrate postpartum. On day four postpartum, cows were switched abruptly to the

postpartum ration for a nine-week period. The buffered rations contained sodium bicarbonate at 0.6% of DM prepartum and at 0.7% of DM postpartum. The average daily dry-matter intake ($g/kg^{\cdot 75}$) for treatment b (170.3) was greater ($P<0.01$) than that of treatments a or c (149.0 and 153.5). Average production of 4.0% fat-corrected milk (kg/d) was greater ($P<0.01$) for treatments b and c (31.5 and 31.7) than that of treatment a (28.7). Average milk fat tests for treatments a, b, and c (3.88%, 3.92%, and 3.90%) were not different. Cows fed the buffered rations lost body weight between weeks one and nine (-19.9 kg for treatment b and -32.1 kg for treatment c), compared to a net gain (+4.9 kg) for cows on treatment a. Cows on treatments b and c consumed more ($P<0.05$) DM ($g/kg^{\cdot 75}$) during week one (109.2 and 109.1) and week two (134.2 and 138.4) than did the cows on treatment a (89.0 during week one and 115.1 during week two). Compared to controls, the cows fed sodium bicarbonate adapted to the rations more rapidly postpartum as indicated by increased intake during the first two weeks and by increased milk production during the nine-week trial.

Title: Brown Midrib Corn Silage for Ruminants

Leaders: L. D. Muller, E. Block, D. L. Garwood (The Pennsylvania State University)

The existence of brown midrib (BM) mutants (low lignin) of corn has been known for many years; however, only recently has research evaluated their nutritive value for ruminants. A trial was conducted evaluating brown midrib (BM_3) corn and an isogenic normal (N) harvested as whole plant (WP) or stover (ST), and preserved as silage (S) or frozen fresh (F) in a 2^3 factorial experiment. Four growing wethers were assigned to each of the eight diets. Lignin content (DM basis) of the BM_3 corn was from 1.2 to 2.0 percentage units lower than that of N. Digestion coefficients for DM, NDF, ADF, and energy were 5.7, 11.3, 11.6, and 6.6 percentage units greater for BM_3 than for N. Digestible DM intakes within silages were 0.86, 0.67, 0.59, and 0.33 kg/day and within the fresh material were 0.80, 0.79, 0.52, and 0.40 kg/day for BM_3WP, NWP, BM_3ST, and NST. The digestible energy contents of diets were higher for BM_3 (3.63) than for N (2.64), higher for WP (3.04) than for ST (2.48), and similar for S (2.75) and F (2.76). The reduced lignin in BM_3 corn plants is the major factor involved with improved intake and digestibility in WP and ST corn silages by sheep.

Research has been initiated to evaluate the nutritive value of BM_3 corn silage for early lactation Holstein cows. Previous researchers have reported that lactating cows fed BM_3 corn silage consume more dry matter and gain more body weight but do not produce more milk. Studies are examining the alteration of ration soluble-protein content as a possible factor causing this response in dairy cattle.

Title: Factors Contributing to Hypomagnesemia in Lactating Angus and Angus-Charolais Cows on Pasture

Leaders: D. D. Fisher, L. L. Wilson, P. J. LeVan, R. W. Scholz, and W. C. Stringer (The Pennsylvania State University)

Factors contributing to hypomagnesemia in lactating beef cows which rotationally grazed tall fescue, orchardgrass, and bromegrass pastures with and without birdsfoot trefoil during a 154-day season were studied. Soil, forage, cow-blood, and urine samples were collected for macro-mineral analysis. Botanical compositions were determined. Meteorological conditions were recorded. No significant differences in pasture-soil composition were detected. Legumes contained more N and Ca ($P<0.01$) than did grasses. Legumes, nitrogen (N)-fertilized grasses, and unfertilized (no N) grasses all differed in Mg ($P<0.05$). Fourteen cows grazing N-fertilized grasses had lower blood- and urinary-Mg levels ($P<0.01$) than did 10 grass-legume cows on similar Mg intakes/animal unit. The N-fertilized grass group had higher forage K intake. Highest blood- and urinary-Mg levels occurred on bromegrass; blood Mg on tall fescue was intermediate and lowest blood Mg was on orchardgrass ($P<0.01$). Cows had a higher blood Ca ($P<0.01$) and lower blood K ($P<0.01$) on bromegrass and lower urinary Ca ($P<0.05$) and higher urinary K ($P<0.05$) on orchardgrass. Three young cows had higher blood Ca, Mg ($P<0.01$), and K ($P<0.05$) than did 21 mature cows; 11 Angus cows had lower blood Mg ($P<0.07$) than did 10 Angus-Charolais. Work is continuing in the analysis of hair samples obtained periodically throughout the trial and on organ samples taken at slaughter.

Title: Intestinal Microorganisms and Their Contribution to Animal Nutrition

Leader: L. L. Slyter (Beltsville Agricultural Research Center)

Preceding each one-week sampling period in a 5x5 Latin square trial, steers (350 kg initial wt) were adapted for three weeks to ad lib intake of hay (H) or corn-based all-concentrates (C). Rumen contents were then totally removed and replaced by digesta from C or H adapted steers. C was then fed one week while rumen digesta was sampled and feed and water intake measured. For all treatments, C intake was greatest between 8 am and noon (Mean, 30% of daily intake). Numbers of bacteria and protozoa and VFA fermentation patterns differed initially due to type of inoculum but did not differ after day 3. Feed and water intake/day tended to be less for body unadapted, rumen adapted steers (9, 16.1 kg, respectively) than for body adapted, rumen unadapted steers (10.1, 17.1) indicating prior body adaptation to C may be more important than rumen microbe adaptation in getting cattle to full C intake. *In vitro*, lactic fermentation was reduced more at pH 5.0 in H than in C rumen digesta. In an *in vitro* trial, nitrogen uptake for microbial protein synthesis of

ruminal microorganisms was compared using fermentors supplied urea (U), uric acid (UA), or caged layer waste (CLW), and basal diets consisting mainly of cornmeal (63%) and cornstalks (35%). Microbial protein production was measured as diaminopimelic acid, ^{15}N, and precipital nitrogen, respectively, in both an isolated bacterial fraction and in the total effluent. Once ammonia began to accumulate at 13.1% CP, little further benefit to bacterial synthesis occurred from additional NPN regardless of nitrogen source.

Title: Influence of Heat and Other Processing Variables on the Utilization of Forage Nitrogen

Leaders: H. K. Goering and D. R. Waldo (Beltsville Agricultural Research Center)

A variety of high-sugar sorghum and one of a sorghum-sudan forage were planted, harvested, and ensiled in 4' x 8' silos without and with sodium benzoate. The silage was fed to Holstein heifers to determine intake potential. Sugar composition was 7.58% in dry matter for the Sweet Sioux forage and 9.89% for the sorghum-sudan hybrid. These sugars were not as high as planned. Dry matter content averaged 28.1% and was similar for all treatments. All pHs of the silage were less than 4. No apparent differences were observed between treatments in recovery of energy and nitrogen. Heifer intake was 1.42, 1.45, 1.92, and 2.11 for the Sweet Sioux-no benzoate, Sweet Sioux-added benzoate, sorghum sudan-no benzoate, and sorghum-sudan-added benzoate, respectively. Dry matter intake of the sorghum sudan variety was greater than that of the Sweet Sioux. Ammonia nitrogen was higher in the forage immediately after adding sodium benzoate. Whole corn plant in the hard-dent stage was chopped and ensiled in 3.03 x 10.7 m silos without and with 500 g/ton of a silage bacterial inoculant (Sila-Bac$_{TM}$). Energy recovery was 80.9 and 78.4%. Lactic acid in the dry matter and pH were 3.2%, 4.0 and 2.8%, 4.2. Energy digestibility was 68.7 and 67.8%. Silage was fed ad lib with a soybean meal-mineral mix to meet protein need of 24 Holstein heifers to determine intake and growth rate. Average daily gain for the 91-day period was 990 and 945 g. Daily intake was 300 and 299 kcal digestible energy/kg$\cdot^{75}$.

Title: Creep Grazing for Beef Production

Leaders: E. C. Prigge and W. B. Bryan (West Virginia University)

A total of 36 cow-calf units were placed on replicated pasture treatments consisting of (1) 2.9 ha of tall fescue (fescue), (2) 1.9 ha of tall fescue and 1 ha of bluegrass-white clover (fescue-creep), and (3) 2.9 ha

of a pasture containing a mixture of cool season grasses and legumes (mixed grass/legume). On the pasture with the fescue and bluegrass/white clover, the pasture was partitioned by a creep gate to allow only calves access to the bluegrass/white clover portion of the pasture. All pastures were quite variable in botanical composition; the tall fescue pastures contained 15 to 20% weeds and other grasses with less than 5% legumes. The mixed-grass/legume pastures consisted of 50-65% Kentucky bluegrass, 5 to 15% legume and 15 to 30% other grasses and weeds. The weaning weights of the calves were 180 kg for the fescue pasture, 196 kg for the fescue-creep, and 200 kg for the mixed grass/legume pasture. The milk production of the cows averaged 4.2, 4.1 and 5.2 kg for the fescue, fescue-creep and mixed grass/legume pastures, respectively. All calves were weaned after 156 days on pasture. Cows were removed from the fescue and fescue-creep pastures after a total of 187 days and from the mixed-grass/legume pastures after 156 days. Cow weights were slightly superior for the fescue treatment when removed from the experimental pastures. Dry matter available on the pasture reached a maximum in late June (3,000-4,000 kg/ha for the tall fescue pastures and 2,000-3,000 kg/ha for the native pastures). In general, pasture available decreased steadily from July through November; however, the creep sections maintained available dry matter at 1,500 to 2,000 kg/ha through October.

Title: Comparison of Soybean Meal, Urea, Dehydrated Poultry Excreta (DPE), and Broiler Litter (BL) as Nitrogen Sources for Lambs

Leader: L. W. Smith (Beltsville Agricultural Research Center)

Two experiments were conducted, each with 20 lambs averaging 32.8 kg initial body weight. In both experiments, 5 lambs were randomly assigned 1 of 4 complete pelleted diets computed to contain a minimum of 74% TDN, 10.9% crude protein, 0.41% P, 0.30% S, 0.08% Mg., 0.70% K, and a maximum of 0.62% Ca. Nitrogen (N) supplements and their contribution to total dietary N were soybean meal, 35; urea, 26; DPE, 32; and BL, 36%. Other ingredients were corn stover, corn meal, limestone, dicalcium phosphate, sulfur, MgO, salt, and vitamins A and D. Lambs were individually fed ad libitum for 45 days in both trials. In experiment I, mean dry-matter intake (1.4 kg/day), gain (282 g/day), and feed:gain ratio (5.2) were not different ($P>0.10$) for source of N supplement in the diets. In experiment II, dry matter intakes were 1.2, 1.2, 1.3, and 1.4 kg daily; gains were 81, 133, 157, and 175 g daily; and feed:gain ratios were 18.1, 10.8, 8.8, and 8.5 for diets supplemented with soybean meal, urea, DPE, and BL, respectively. The faster gain in experiment I may have been the result of compensatory growth. BL and DPE were equal or superior to soybean meal or urea as N supplements for lambs.

Title: Quality of Timothy Hay as Affected by Magnesium Fertilization

Leaders: R. L. Reid, B. S. Baker, and G. A. Jung (West Virginia University and U.S. Regional Pasture Research Laboratory)

Timothy (Phleum pratense L.) is generally a low Mg accumulator species. In one series of trials, replicated stands of timothy on a farm in the Allegheny Highlands Project, W.Va., were grown with and without kieserite (390 kg Mg/ha as $MgSO_4.H_2O$), harvested as a first cutting hay and fed to wether sheep in intake and mineral balance trials. Fertilization increased the Mg concentration from 0.08 to 0.16%. Control hays were fed with and without a Mg supplement (5 g $MgSO_4.7H_2O$/day in the water) to supply approximately the same concentration of dietary Mg as the fertilized hay. Both Mg supplemented and fertilized hays increased ($P<0.01$) serum Mg % and Mg retention in lambs, with a larger response from the supplement. Neither supplement nor fertilizer affected DMD (%) but supplement increased intake significantly (mean of 61.3 vs 66.9 g/Kg $BW^{.75}$ for control and supplemented hays, respectively). In other trials, cultivars of timothy (Timfor and Climax) selected as high and low Mg accumulators on the basis of greenhouse experiments, were grown in field trials with and without kieserite fertilization at Rock Springs Agricultural Research Center, Pa., and fed in intake and balance studies to beef cows and sheep. Differences in Mg concentration between cultivars under field conditions were minor, and no differences ($P>0.05$) in intake or DMD due to cultivar or fertilization were noted. Cattle and sheep differed ($P<0.01$) in DMD and mineral retention, but not in level of intake.

Title: Studies on Allelochemical Properties of Crownvetch and Their Effects on Forage Quality

Leaders: D. L. Gustine and B. G. Moyer (U.S. Regional Pasture Research Laboratory)

We have established the presence of 10-12 3-nitropropanoyl-D-glucose compounds in crownvetch. Structures for five such compounds have been identified, but others that occur in trace quantities in crownvetch have not been identified. To aid us in the identifications, we examined seeds from Corynocarpus laevagatus. A new compound and three others that also occur in crownvetch were isolated and identified. The new structure was 1,4,6-tri-(3-nitropanoyl)-B-D-glucopyranose and the compound was named corynocarpin. The other three were cibarian, coronarian, and corollin. The structures were established by 220 MHz proton magnetic-resonance spectra.

Title: Comparison of Winter Hay Feeding Systems for Beef Heifers

Leaders: D. L. Lee, L. L. Wilson, P. J. LeVan, M. F. Cain, W. L. Kjelgaard, and P. M. Anderson (The Pennsylvania State University)

Eighty-four eight-month-old heifers (42 Angus and 42 Simmental-Angus) were used to evaluate two types of haying systems. Heifers were randomly assigned to wintering lots and fed combinations of corn silage (CS) and hay (680-kg large round bales, LRB, and rectangular bales, RB, fed in covered and non-covered feeding structures) for 84 days. Crude protein and % dry matter (DM) values were not significantly different for RB and LRB but RB contained more available protein, 14 vs 12.1%. Percent hay wasted was similar for the covered and non-covered RB groups, 0.94 and 2.1%. When fed equal amounts of CS as the RB groups (1/4 of NRC DM recommendations as CS), the covered and non-covered LRB groups wasted 9.8 and 18.5%, respectively, of the hay fed. When averaged over both CS groups (1/4 and 1/2 of NRC DM recommendations as CS), LRB losses for covered and non-covered groups were 13 and 23%, respectively. Significant differences in average daily gain ($P<0.05$) were observed between covered RB and non-covered RB (0.53 vs 0.44 kg/day). These heifers were bred and 72 were used the following winter to evaluate differences in feeding systems using rectangular bales (RB), small (SRB), and large round bales (LRB). The latter two package types were fed in both fenceline and elevated feeders. Percent DM averaged 87, 70, and 67.5% for the RB, LRB, and SRB. Again, crude protein values were not significantly different, but available protein was highest for the RB, 12.6% vs 12.1 and 11.8% for the SRB and LRB. More hay DM (32%) was required for the LRB fed in fenceline feeders, and 36% more for LRB fed in an elevated feeder compared to the amount of RB hay required. Heifers fed SRB, elevated or in fenceline feeders, gained significantly ($P<0.05$) less than heifers fed LRB or RB.

Title: Blood and Salivary Composition of Lactating Beef Cows and Mineral Utilization by Sheep on Magnesium Fertilized Spring Pasture

Leaders: J. K. Thompson, R. L. Reid, and G. Mandata (School of Agriculture, Aberdeen Scotland, and West Virginia University)

Replicated orchardgrass pastures (0.7 ha) were treated with and without kieserite fertilizer at the rate of 2,240 kg/ha (equivalent to 390 kg Mg/ha). All pastures received nitrogen (112 kg N/ha as ammonium nitrate) in early spring. Twenty-four mature, lactating beef cows (Angus and Hereford) were allocated to treatments on the basis of previous blood Mg status, and jugular blood and saliva samples were taken during a 2 week period after turning the cows on pasture. Fresh herbage from the pastures was cut and fed in digestion and mineral balance trials to

mature wether sheep (6 per treatment). Fertilization increased ($P<0.05$) the Mg and S concentration of the pasture (means 0.22 and 0.29% Mg, and 0.20 and 0.29% S for control and kieserite treatments, respectively). Magnesium fertilization caused a slight, but non-significant, increase in serum Mg (1.62 vs 1.73 mg/100 ml for control and treated groups, respectively), ultrafiltrable Mg (1.13 vs 1.21 mg/100 ml) and red blood cell (RBC) Mg (1.34 vs 1.44 mg/100 ml), but had no effect ($P>0.05$) on serum Ca, inorganic P, K, or Na, ultrafiltrable Ca, packed cell volume (PCV) or salivary Na, K, or P concentrations. All of these measurements, with the exception of serum Ca, showed changes ($P<0.01$) with period or days after beginning of grazing, and there were significant period x treatment effects on serum Na, ultrafiltrable Ca and salivary Na, K, and P. Balance trials with sheep on grass cut during the same period showed a higher apparent absorption of Mg (36.5 vs 24.5%) and S (66.9 vs 58.6%) on kieserite-fertilized compared with control herbage. Sheep fed fertilized grass retained an estimated 0.60 g Mg/day vs 0.16 g Mg/day by sheep on non-fertilized orchardgrass.

Title: Energy Value of Feedstuffs of Dairy Cattle

Leaders: P. W. Moe and H. F. Tyrrell (Beltsville Agricultural Research Center)

A total of 103 energy and nitrogen balance measurements were completed on Holstein cows representing three stages of lactation plus the dry period. Cows were continuously fed one of six corn silage based rations (60:40 corn silage:concentrate on DM basis) containing either 11, 14, or 17% protein without or with 2.5% ground limestone as a buffer. Unbuffered rations were formulated to be adequate (1978, NRC) in all nutrients except protein and were fed either ad libitum (early lactation) or in amounts adequate to meet 1978 NRC requirements for NE_l. During early lactation, intake of both DE (62.6 vs 36.6 Mcal) and ME (55.1 vs 32.4 Mcal) were higher for the 17% than the 11% protein rations without limestone. Limestone increased DE intake 5.4 Mcal on the low protein ration but decreased intake 9.6 Mcal on the 17% ration. Dietary treatment had no effect on partial efficiency of ME use for milk plus body tissue. Daily yield of protein in milk was 1.02 kg for 17% vs 0.67 kg for 11% protein during early lactation. Part of the increase in intake of ME is attributable to greater intake of dry matter. However, ME as percent of total energy intake averaged 50.8, 54.4, and 56.8 for the 11, 14, and 17% unbuffered rations during lactation compared to 59.0, 59.6, and 57.5% during the dry period. Addition of limestone buffer was not associated with any substantial improvement in ME value. This study demonstrates the requirement for at least 17% crude protein in the ration of dairy cows during early lactation for maximum milk yield.

Title: Microbiological Aspects of Digestion and Use of Cellulosic Crop Residues by Ruminants

Leader: M. E. Simpson (Beltsville Agricultural Research Center)

A mature beef steer was fed a forage diet twice daily followed by feeding the same diet supplemented with 30 ppm monensin. Volatile fatty acid (VFA) composition of the ruminal fluid was determined for one week before and for 18 days after addition of monensin to the diet. During the control week and for days 8-11 and 15-18, ruminal contents were sampled at 4 and 8 hr after the morning feeding. For days 1-4 of feeding monensin, samples were taken 1, 2, 4, 6, 8, and 10 hours after the morning feeding. VFA determinations were made on acidified ruminal fluid by gas chromatography. During the 4 days of sampling of the control week, daily averages for total VFA content were 81.85, 76.58, 82.92, and 87.04. The daily acetate:propionate (C2:C3) ratios were 3.52, 3.57, 3.50, and 3.52; butyrate:propionate (C4:C3) ratios were 0.61, 0.59, 0.56, and 0.58. After addition of monensin to the diet, total VFA content averaged 83.82, 95.14, and 82.93 for days 1-4, 8-11, and 15-18 of the adaptation period, respectively. For days 1-4, the average daily values of the C2:C3 ratio were 3.37, 2.34, 1.96, and 1.87; for C4:C3 ratio, the corresponding values were 0.56, 0.37, 0.32, and 0.30. For days 8-11 and 15-18, the average values for C2:C3 were 2.29 and 2.51; and for C4:C3, 0.37 and 0.40. The results show that during the first few days of the adaptation period, propionate became a larger proportion of the total VFA content of ruminal fluid; acetate and butyrate concentrations were decreased. Propionate content continued to increase through the fourth day but had plateaued by the eighth day. Total VFA content was not significantly changed ($P \leq 0.05$) during the course of this study.

Title: Utilization of Non-protein Nitrogen by Continuous *In Vitro* Cultures of Ruminal Microorganisms

Leaders: G. Varga and E. C. Leffel (University of Maryland)

The utilization of urea (U), uric acid (UA), and caged-layer waste (CLW) by ruminal microorganisms was compared in 12 continuously cultured fermenters. Two basal diets were used to determine whether quality of diet would affect nutrient digestibility and utilization of nitrogen from the three different sources. The design was a randomized complete block, split plot in time, with a 3 X 4 factorial arrangement of treatments. The three nitrogen sources were administered at four levels of crude protein: 8.3, 9.8, 11.3, 13.3 and 10.75, 13.3, 14.2, and 16% for the high roughage (HR) and high concentrate (HC) diets, respectively. One replication consisted of the three nitrogen sources at four levels of crude protein with either the HC or HR diet being administered. U and UA were continuously infused with the artificial saliva solution.

CLW was incorporated into the total diet to obtain the same total digestible nutrients as the basal diets and crude protein levels as the U and UA treatments.

The following are the results for the HR diet: total volatile fatty acid (TVFA) concentration (μm/ml), VFA carbon (mm/d), and acetate: propionate (A:P) ratios were: 100.6^{b}, 99.5^{b}, 93.3^{c}; 193.3^{b}, 192.1^{b}, 176.8^{c}; 3.6^{b}, 3.2^{c}, 3.5^{bc} ($P<0.01$) for the U, UA, and CLW, respectively. There was a significant ($P<0.01$) effect for level as the crude protein content was increased in the diet. Protozoa ($X\ 10^{3}/g$) and ammonia nitrogen (mg/100 ml) were: 4.9^{b}, 3.5^{b}, 11.9^{b}; 11.8^{b}, 10.3^{b}, and 4.4^{b} ($P<0.05$) for the U, UA, and CLW, respectively. Ammonia nitrogen increased ($P<0.01$) as crude protein level increased. Methane (mM/d) and carbon dioxide (mM/d) were 18^{b}, 15.7^{c}, 15.5^{c}; 99.7^{b}, 103.1^{b}, and 88.3^{c} ($P<0.05$) for the U, UA, and CLW, respectively. Only carbon dioxide showed significant ($P<0.01$) increase as level of protein in the diet increased. Digestibility of dry matter (DM), organic matter (OM), neutral (NDF) and acid detergent fiber (ADF), and cellulose were all significantly higher ($P<0.05$) for the CLW treatment. There were no level effects for any of these variables.

The following are the results for the HC diet: TVFA, VFA carbon, and A:P ratios were: 118.9^{b}, 119.9^{b}, 101.2^{c}; 234.2^{b}, 215^{b}, 175.2^{c} ($P<0.05$) for the U, UA, and CLW, respectively. A:P showed a significant ($P<.01$) level effect. Protozoa ($A\ 10^{3}/g$) and ammonia nitrogen (mg/100 ml) were: 7.5^{b}, 3.0^{b}, 18.1^{c}; 7.5^{b}, 3.7^{c}, 4.5^{c} ($P<0.01$) with increasing crude protein content in the diet. Digestibility of NDF and ADF and hemicellulose were significantly ($P<0.05$) higher for the CLW. Significant ($P<0.05$) level effects were observed for digestibility of OM, NDF, ADF, cellulose, and hemicellulose.

The results indicate CLW can be used as effectively as can urea or uric acid by ruminal microorganisms *in vitro*.

Bacterial protein produced was determined by using diaminopimelic acid as a marker, N-15 analysis, as well as true protein measurements.

Title: Selenium Status of Beef Cattle and Sheep in Pennsylvania and West Virginia

Leaders: Donna L. Stadtmore, R. L. Reid, and G. A. Jung (West Virginia University and U.S. Regional Pasture Research Laboratory)

A survey was conducted to determine the selenium (Se) status of beef cows and ewes on summer pastures in 14 counties in southwest Pa. and northern W.Va. Whole jugular blood was taken from 15 animals per herd or flock and analyzed for Se and glutathione peroxidase (GSH-Px) activity. For all lactating cows (251), Se content (ppm) and GSH-Px

activity (EU/gHb) ranged from 0.06-0.29 and 52-257, respectively, with a mean of 0.12 ppm Se and 121 EU/gHb GSH-Px. These values were consistently lower ($P<0.01$) than for sheep. Range of Se content and GSH-Px activity for ewes (225) was 0.07-0.30 and 52-310, respectively, with mean values of 0.16 ppm Se and 183 EU/gHb GSH-Px. Mean values for all animals in Pa. were 0.18 ppm Se and 169 EU/gHb GSH-Px compared to 0.12 ppm Se and 142 EU/gHb GSH-Px in W.Va., possibly reflecting proximity to industrial sites. For cows, blood Se and GSH-Px varied highly ($P<0.01$) between counties, with less variation ($P<0.05$) for Se between herds within a county; GSH-Px activity differed markedly ($P<0.01$) between herds within a county. For sheep, Se levels and GSH-Px activity were highly variable ($P<0.01$) between counties; Se levels also differed ($P<0.01$) between flocks within a county, but differences between GSH-Px activities were not significant. For both cattle and sheep, regressions of GSH-Px activity on blood Se were significant ($P<0.05$), but variability was sufficiently high to limit use of the GSH-Px assay for predictive purposes. Analysis of pasture samples showed a range of 0.09-0.24 ppm Se in air-dried herbage. There was a correlation of +0.80 ($P<0.01$) between Se concentrations of pasture and mean whole blood Se content for all herds and flocks in the survey.

Title: Feeding Dried Immature Forages as Grain Substitutes for Ruminants

Leader: Martin R. Stokes (University of Maine)

Digestibility and energy metabolism studies on two forms of two immature forages have been completed with sheep as part of an evaluation of the nutritional characteristics and utilization of processed immature forages as substitutes for feed grains. Timothy and alfalfa harvested at immature stages under the agronomic phase of this project have been dried and then chopped or chopped and pelleted. Preliminary analysis of digestibility-trial data indicates that at the maintenance level of feeding there is no difference between forms of a forage within a forage type. There also appears to be little difference between immature timothy and immature alfalfa in the digestibility of dry matter and gross energy. With alfalfa, digestibility of neutral detergent fiber was lower and of crude protein higher than with timothy. Analysis of energy metabolism data is continuing. The nitrogen fraction of each feed form will be partitioned and the amino acid profile of each protein fraction determined. A complete carbohydrate fractionation will also be performed. This data will contribute to the regional objective of identifying key physical and chemical factors influencing forage intake and digestibility.

Title: Performance and Volatile-Fatty-Acid Production of Lambs Fed Buffers in Diets Varying in Forage:Concentrate Ratios

Leaders: M. J. David and E. C. Leffel (University of Maryland)

A 3 X 3 factorially designed experiment replicated three times was conducted to determine the effect of buffer supplements on performance and rumen volatile-fatty-acid (VFA) production of ewe lambs consuming diets which varied in roughage:concentrate ratios. The forage:concentrate ratios of the three diets were 80:20, 50:50, and 20:80 each of which was supplemented with either no buffer, 2% sodium bicarbonate, or 2% sodium bicarbonate + 2% limestone. Rumen, fecal, and urine pH were measured during the trial.

Diet had the greatest influence on animal performance and rumen VFA production. Decreasing the forage level from 80 to 20% improved ($P<0.05$) average daily gain (ADG) and feed conversion (G/I), increased ($P<0.05$) the rumen concentration of propionate and valerate, and decreased ($P<0.05$) the rumen pH and the concentration of acetate. The rumen concentration of butyrate increased ($P<0.05$) in lambs fed the moderate grain rations, and the rumen concentration of isovalerate increased over time in lambs fed high grain diets, but decreased in lambs fed the moderate and low grain diets. Lambs consuming the moderate grain diets had a greater ($P<0.05$) average daily intake (ADI) than lambs consuming either the low or high grain diets. The ADI of lambs consuming low grain diets increased towards the end of the trial. Urine pH was not affected by diet, but fecal pH was lowered ($P<0.05$) as the concentrate level in the diet was incremented.

The feeding of 2% sodium bicarbonate or 2% sodium bicarbonate + 2% limestone had no influence on ADG, ADI, and G/I. The rumen VFA profile was also not markedly affected by treatment. Buffer supplements had no effect on rumen pH, on the concentration of total VFA, and on the concentrations of propionate, butyrate, and valerate. Diets containing either buffer supplement increased ($P<0.05$) the rumen concentration of isobutyrate and, generally, also that of isovalerate. Treatment did tend to stabilize rumen conditions as evidenced by the more predictable and constant levels of rumen acetate in lambs fed the buffered diets.

Both levels of buffer increased the molar percent of isovalerate, but the feeding of 2% sodium bicarbonate in high grain diets lowered ($P<0.05$) the molar percent of valerate. The molar percent of acetate and the acetate:propionate ratio tended to increase initially in the rumen of lambs fed buffers in the high and moderate grain diets, but then decreased and approached control levels after the fourth week of the trial. The feeding of both buffer supplements raised ($P<0.05$) urine pH; however, fecal pH increased ($P<0.05$) only in lambs fed diets containing 2% sodium bicarbonate + 2% limestone.

Title: Formaldehyde and Other Additives for Ensiling Forages

Leaders: D. R. Waldo and H. K. Goering (Beltsville Agricultural Research Center)

The decreased growth and nitrogen retention from feeding untreated, direct-cut, hay-crop silage can be corrected by treating the silage with formaldehyde. Formaldehyde increases the preservation of protein in silage. Companion calorimetric experiments have demonstrated no reduction in energy retention, comparable to the reduced growth, when feeding untreated silage. Chemical analysis of empty body tissue pre- and post-feeding of these silages demonstrated some, but a much smaller, decrease in energy retention than in daily gain when feeding untreated silage. When feeding untreated silage a larger fraction of the energy was a high energy fat and a smaller fraction was as lower energy protein, i.e., equivalent energy was stored in less weight. In addition, three weights of water are retained for each weight of protein so the weight gain for equivalent energy was reduced even more. Ninety percent of the difference in protein retention may be attributed to differences in insoluble or undegraded protein intake. Feed intake of corn silage based rations was increased slightly by the addition of extra limestone (Ca) or dried poultry excreta (DPE) at feeding but decreased slightly by Ca and DPE additions at ensiling. Fat-corrected milk production and weight were increased most by Ca addition at feeding and lesser amounts by DPE at feeding and Ca and DPE additional at ensiling. Ca and DPE additions at feeding increased starch digestion and fecal pH more than Ca and DPE additions at ensiling.

Title: The BARC Forage Research Program with Sheep

Leader: G. P. Lynch (Beltsville Agricultural Research Center)

A forage program is in the process of being developed with the sheep research flock at BARC. The flock consists of about 300 commercial ewes and will be utilized primarily for nutrition studies. The forage program will consist of summer grazing studies with lambs and ewes and winter feeding studies that will include silage feeding trials with gestating and lactating ewes. Summer grazed lambs will be given various pasture supplements to promote optimal production. Winter silage feeding will be evaluated in terms of milk production and lamb growth. The primary nutritional emphasis will be directed towards protein and mineral nutrition.

Title: Alfalfa-Corn Stover Silage for Replacement Dairy Animals

Leader: J. H. Vandersall (University of Maryland)

An additional trial was conducted to compare wilted-alfalfa silage to direct-cut alfalfa silage to which corn stover has been added before ensiling. The direct-cut silage with stover added was composed of two-thirds alfalfa and one-third corn stover on an as-harvested basis. The alfalfa was 28% dry matter and the corn stover 72% dry matter, making the silage approximately 56% stover and 44% alfalfa on a dry matter basis. The wilted silage was 45% dry matter.

Sixteen yearling dairy animals (6 heifers and 10 steers) were paired and randomly assigned to the two silages. Each animal was fed 1.81 kg of concentrate per day. The average body-weight gain during the 8-week trial was 823 grams for the animals fed wilted silage and 494 grams for those fed the alfalfa-stover silage. Digestion trials were conducted using 4 steers in each forage group. The animals fed the alfalfa-stover silage did not grow as well as desired; however, they showed no signs of stunting. Less stover should be used in such silages or more concentrate should be fed to obtain satisfactory growth.

Title: Optimizing Intake and Digestibility of Forages

Leaders: P. J. Wangsness, J. S. Shenk, H. W. Harpster, E. Keck, W. L. Kjelgaard, and W. C. Templeton, Jr. (The Pennsylvania State University and U.S. Regional Pasture Research Laboratory)

More reliable means of predicting voluntary intake of forages by animals from easily measured dietary and animal characteristics will aid in optimizing use of forages in ruminant diets and will enable a more meaningful evaluation of forage quality. New technology involving infrared reflectance offers another potential way of evaluating forage nutritive value and either alone, or in combination with presently used lab measurements on diets, offers potential for more accurate prediction of forage intake. A two-year trial is underway which will involve feeding 60 different forages to sheep. Voluntary intake, *in vivo* digestion, and digestible energy intake of the forages will be determined. All sheep will be fed the same standard hay for 7 days prior to each experimental period; this procedure should allow for a more accurate measurement of experimental forage treatment effects. Various laboratory measurements of the forages, including NDF, *in vitro* digestibility and rate of NDF digestion, density, and infrared reflectance spectra of the forages, will be related to the intake and digestion measurements from the sheep. It is hoped that complete data on this large number of forages, the use of the standard hay, and the potential of IR analysis, will aid in developing prediction equations for estimating forage intake from easily measured dietary characteristics.

Title: Optimizing Intake and Digestibility of Forages by Ruminants

Leader: J. G. Welch (University of Vermont)

Factors affecting the passage of large particles from the rumen have been studied in sheep and fistulated steers in 2 x 2 reversal experiments. Cylindrical polyethylene particles 1/2 cm long and hollow (similar to large hay stems) pass from the rumen of cattle much slower than do 1/2 cm long flat polypropylene ribbon pieces. Almost no cylinders pass from the rumen of sheep while flat pieces pass readily. These results indicate that the reticulo-omasal orifice does not function as an open hole during periods of particle passage but performs some sieving action. Maximizing dry matter intake in fistulated steers by feeding hay, concentrate, and alfalfa pellets ad lib increased the rate of passage of particles including 1/2 cm cylinder particles, compared to hay fed controls. Non-ruminated cylinders and flat pieces 1/2 cm long also passed in larger numbers with the maximum dry matter intake treatment. The plastic particles were evenly distributed throughout the semi-solid rumen ingesta. If particle methods are found to increase the average particle size passed through the reticulo-omasal orifice, less rumination will be required per unit of cell wall constituent consumed and roughage intake should be increased. Comparisons of rumination activity and fecal particle size between purebred Holsteins, 3/16 bison, and purebred Scotch Highland cattle indicated that the Scotch Highland produced coarser fecal particle sizes with less rumination than did the other two breeds. The 3/16 bison and the Holstein were similar.

Title: Morphological and Anatomical Traits in Plants Influencing Digestibility

Leaders: J. B. Powell, D. Dinius, P. S. Baenziger, and J. Bond (Beltsville Agricultural Research Center)

Studies have continued to uncover anatomical and morphological traits of forage grasses which can significantly increase rate and extent of digestion. Barley has been used as a test organism because of the availability of large numbers of cuticular mutants in this species. The cuticular waxes have a major effect on digestion of unbroken and undamaged leaves. Recent studies with the scanning electron microscope have revealed the importance of the surface and the attachment process of the microbes. A barley line designated GL-4, which is a mutant of Gateway barley, has significantly higher rates of rumen bacterial penetration. The two lines were selected for seed increase for field tests using ruminant animals. Twenty pounds of seed of the control line Gateway and its mutant line GL-4 have been seeded for performance of growing lambs. The test proposed should permit an assessment of the value of genetically manipulating surface cuticular waxes or surface changes in plants for increased rate and extent of digestion.

Title: Optimizing Intake and Digestibility of Forages by Ruminants: Calcium Nutrition

Leaders: J. L. Evans, Z. Lelkes, P. Zajac, D. Yoon (Rutgers University)

The third major trial referenced in the 1977 report was completed at the animal level, and the dry-period data were summarized. At 60-days prepartum 44 Holstein cows were arranged according to age-at-parturition (25 and 41 months) and randomly assigned to diets containing 0.32 and 0.55% Ca on a dry matter (DM) basis. All diets contained 0.6%P and 0.25% Mg on a DM basis. DM intake was restricted to 10 kg/cow/day with 5 kg from corn silage and 5 kg from concentrate. Total collection, digestibility, and Ca, P, and Mg balance trials were conducted during prepartum days 21 to 17. Grams of apparently-absorbed Ca favored the 0.55% Ca level. Apparent absorption of Ca ranged from 17 to 26%. Endogenous Ca estimated from regression of fecal Ca on ingested Ca was 0.855 g/100 kg body weight. The calculated daily Ca requirement for dry period maintenance (based on determined Ca absorption values) ranged from 31 to 20 g/600 kg cow. Mg intake ranged from 18 to 21 g/cow/day during the dry period with utilization of Mg greater for younger cows (29 versus 23% absorption). Jugular blood samples were obtained on days 40, 20, 10, and 5 before expected parturition and sera assayed for Ca, hydroxyproline (HP), P, and Mg. Older cows had lower serum Ca up to day 10 prepartum, followed by an increase immediately prior to parturition. Younger cows showed a delayed (5 days) increase in serum Ca. Serum HP gradually increased until day 10 prepartum, indicating an increased demand for blood Ca, followed by a decrease, indicating the operation of an effective homeostatic mechanism(s) to maintain blood Ca. Serum Ca and serum HP were not correlated. This result and the observation that a low-Ca diet was associated with elevated serum-HP levels suggest that serum HP can be used as an index of Ca status in cattle. More detailed studies in the rat and guinea pig support the use of HP as an early indicator of subclinical Ca deficiency.

The lactation part of the third major trial (as noted above) should be completed with respect to data analyses. Data summaries will follow. In addition, a fourth lactation trial nears completion at the animal level. Objectives deal with the influence of diet calcium on voluntary dry-matter intake, milk production, and calcium utilization. Diet calcium will be maintained at 60 to 70 grams/cow/day from 60 days precalving to 42 days post-calving. From lactation day 43, responses to 4 diet-calcium levels will be determined. The diet-calcium levels will be 70, 100, 130, and 160 grams/cow/day.

Title: The Effect of Using Ralgro, Stilbestrol, and Thibenzole on Gains of Yearling Steers on Pasture

Leaders: L. Malkus, T. Clay, S. Godber, and D. Magione (University of Connecticut)

A field trial using 66 yearling steers on pasture at Johnny Cake Ranch, Burlington, Conn., was initiated June 9, 1978. Steers were tagged, weighed, and assigned to one of the following groups: Control, Stilbestrol (36 mg. implant), Ralgro (72 mg. implant), Thibenzole (15 gram bolus), Stilbestrol-Thibenzole, and Ralgro-Thibenzole. At the end of a 124-day period (October 11, 1978), the steers were reweighed. The response to various treatments versus no treatment, as measured by the average weight gain for the 11 steers in each group, was 16.9% increase for Ralgro, 14.7% increase for Ralgro-Thibenzole, 12% increase for Stilbestrol, 10.6% increase for Thibenzole, and 6.2% increase for Stilbestrol-Thibenzole. Based on current prices, the practice of worming resulted in about $7.00 profit per steer. The average daily gain per steer disregarding treatment groups was 1.4 pounds or a total gain of 172 pounds. At current prices, this gain would be worth more than $80.00 per steer.

Title: Growth and Physiological Parameters of Ruminants Grazing Different Varieties of Tall Fescue Pasture

Leaders: James Bond and J. B. Powell (Beltsville Agricultural Research Center)

Steers grazed KY 31, Kenhy, or two experimental strains (G1-306, high perloline and G1-307, low perloline) of Festuca arundinacea Schreb. Average daily gain, gain per ha., animal condition, and hair coat scores were all lowest for the steers grazing G1-307. Steers grazing G1-307 showed signs of emaciation, rough hair coat, and elevated respiration and remained under shade most of the daylight hours. Behavioral activity was observed for 24 hours on days one month apart and showed that the steers grazed during the daylight hours except for the steers grazing G1-307 during the first or warmest month. These steers grazed less than the other steers and grazed 58% of the time at night.

Title: Infrared for Evaluating Forage Quality and Nutritive Value

Leaders: J. S. Shenk, M. R. Hoover, M. O. Westerhaus, W. C. Templeton, Jr., G. W. Fissel, and W. G. Lynch (The Pennsylvania State University and U.S. Regional Pasture Research Laboratory)

Testing and validation of near infrared reflectance (IR) technology for assessment of quality and nutritive value of forages continued. Ten computer programs have been developed to operate a spectro-computer system containing a scanning monochromator and 32K-word computer with dual floppy disks. The programs serve to (1) collect, interpret, and manipulate the IR and laboratory data, (2) predict nutritive-parameter values of samples, and (3) monitor and indicate instrument diagnostic problems. New and improved statistical procedures permit extraction of more information from the IR data and result in a 10-30% improvement in prediction accuracy.

First tests of a small IR instrument indicated satisfactory performance for some applications. The 10 programs previously referred to can be used with this less expensive instrument, but rigorous use and testing showed precision to be inadequate and it was returned to the manufacturer for modification and improvement.

New potential applications of IR in forage evaluation include estimation of legume percentage (± 10%) in grass-legume mixtures, heat damaged protein (± 0.06% acid detergent insoluble nitrogen), phosphorus (± 0.04%), calcium (± 0.14%), potassium (± 0.41%), and boron (± 5.4 ppm).

Title: Productivity and Composition of Nitrogen-fertilized Grass and Grass-legume Pastures Under Grazing Conditions

Leaders: D. D. Fisher, L. L. Wilson, P. J. LeVan, and W. C. Stringer (The Pennsylvania State University)

Productivity [dry matter (DM), digestible dry matter (DDM), crude protein (CP) yields; carrying capacity; calf gain/ha; beef-cow weight gain] and composition (botanical, macromineral) of rotationally-grazed pastures of tall fescue, orchardgrass (orchard), and smooth brome (brome), with and without birdsfoot trefoil were evaluated for a 154-day grazing season. Cows on grass-legume pastures gained more weight ($P<0.05$). N-fertilized grasses (168 kg N/ha/yr) yielded 84.7 kg more calf/ha than mixed swards (24% legume). Nitrogen-fertilized fescue and orchard had higher total DM and DDM yields than did grass-trefoil ($P<0.05$). Orchard (+N), brome (+N), orchard-trefoil, and brome-trefoil DM and DDM yields decreased during the latter part of the grazing season ($P<0.05$). Orchard (+N) and brome-trefoil CP yields also decreased ($P<0.05$). Fescue (+N, no N) had higher Mg contents than did brome (+N, no N; $P<0.05$). Orchard (no N) and brome (+N, no N) increased in Ca

content during summer and fall ($P<0.05$). Fescue (+N) was higher in CA during spring and fall ($P<0.05$). Orchard (+N) had elevated K in spring ($P<0.05$). Orchard (no N) and brome (no N) increased in Mg during late summer-fall ($P<0.05$). Orchard (+N) had the highest K/(Ca+Mg) ratio at 2.2.

SECTION IX

SILAGE AND HAY RESEARCH

Title: Use of Silage Preservatives to Reduce Storage Losses

Leader: J. B. Holter (University of New Hampshire)

No results this reporting period.

SECTION X

ENVIRONMENTAL RESEARCH

Title: Effects of Sewage Sludge on Soils and Yield of Corn and Soybeans

Leaders: A. M. Decker, R. L. Chaney, and W. E. Beers (University of Maryland and Beltsville Agricultural Research Center)

Winter forage crops of cereal rye, corn, and soybeans were grown for the seventh season on soil treated once in 1972 with 0, 56, 112, and 224 metric dry tons/hectare of digested sewage sludge. As in past years, 90 kg each of P_2O_5 and K_2O were applied to all fertilized plots; in addition all fertilized corn plots received 180 kg N/ha.

Rye yields were significantly higher at the 112 and 224 ton rate on both the corn and soybean plots. There was a tendency for higher yields on the fertilizer plots, especially on the corn plots. Corn silage yields on the 56-ton sludge-no fertilizer treatment were double those on the no sludge-no fertilizer treatment; all other treatments were similar and significantly higher than these two treatments. Corn grain yields followed a pattern similar to silage. There was a tendency for soybean yields to be higher at the high sludge rates, but these differences were small.

Title: Feasibility of Using Sewage Sludge for Plant and Animal Production

Leaders: A. M. Decker, J. P. Davidson, R. L. Chaney, S. B. Mohanty, and R. C. Hammond (University of Maryland and Beltsville Agricultural Research Center)

Pastures of predominantly tall fescue were treated with liquid digested sewage sludge and raw sludge compost in 1976, 1977, and 1978. Liquid sludge was applied 21 days before grazing (in 1976 it was also added one day before grazing following 21 days regrowth of the pasture). Compost was applied three times in 1977 and twice in 1978. Rates of liquid sludge and compost were selected to supply nitrogen equivalent to 50 kg N/ha as NH_4NO_3 applied at the same times as the liquid sludge.

The "high-iron" sludge (11%) used in 1976 resulted in very poor animal performance (1977 report, page 78). Arthritic erosion of articular cartilage noted in the tibial-tarsel joint, which appeared to be sludge-related, in 1976-77 was not observed in 1978. A controlled feeding study is presently underway attempting to clarify these and other findings. In 1978 animals on compost-treated pastures performed equally as well as those maintained on pastures fertilized with NH_4NO_3.

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RECIPIENTS OF
GRADUATE DEGREES

--M.S. DEGREES--

Name - Institution - Advisor	Thesis Title
R. HEISEY Cornell University (R. P. Murphy)	An investigation of techniques and methods useful in breeding alfalfa for resistance to Phytophthora root rot.
MICHAEL J. DAVID University of Maryland (E. C. Leffel)	Performance and Volatile Fatty Acid Production of Lambs Fed Buffers in Diets Varying in Forage:Concentrate Ratios
J. A. PLUMMER The Pennsylvania State University (R. A. Byers)	Biology and Life Table Analysis of the Alfalfa Blotch Leafminer, Agromyza frontella (Rondani) (Diptera:Agromyzidae), on Alfalfa in Central Pennsylvania
K. RAJAGOPALAN University of Massachusetts (R. E. Mudgett)	Single Cell Protein Production from Alfalfa Process Wastes
H. E. REED The Pennsylvania State University (R. A. Byers)	The Role of Phyllotreta cruciferae and P. striolata (Coleoptera:Chrysomelidae) in Production of Forage Brassicas
J. E. SUMBERG Cornell University (R. P. Murphy)	Effects of managements and varieties on yield and quality of alfalfa (Medicago sativa L.) forage.
TRAN VAN TOAI Cornell University (D. L. Linscott)	Some Allelopathy Effects of Decaying Quackgrass (Agropyron repens L.) Residues on the Growth of Seedling Alfalfa (Medicago sativa L.)

--Ph.D. DEGREES--

R. BAJARACHARYA University of Massachusetts (R. E. Mudgett)	Effects of Controlled Gaseous Environments in Solid-Substrate Fermentations
CHARLES H. DARRAH, III Cornell University (G. W. Fick)	Lipid changes in alfalfa (Medicago sativa L. and Medicago falcata L.) during cold acclimation.
E. ALARCON-MILLAN Cornell University (L. V. Crowder)	Influence of ploidy level on the fertility and nutritive value of Medicago species, and inheritance of digestibility in tetraploid Medicago sativa L.

Name - Institution - Advisor	Thesis Title
T. R. PEOPLES University of New Hampshire (D. W. Koch)	The role of potassium in carbon dioxide metabolism, growth, and yield of alfalfa.
J. E. SUMBERG Cornell University (R. P. Murphy)	Studies on the expression and inheritance of some components of nutritional quality in alfalfa (*Medicago sativa* L.) forage.
GABRIELLA A. VARGA University of Maryland (E. C. Leffel)	The Utilization of Uria, Uric Acid, and Caged Layer Waste by Rumen Microorganisms *In Vitro*

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